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THE NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

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FINAL REPORT
FOR THE DEPARTMENT OF ENERGY
AND THE NEW ENGLAND STATES

• Appendices

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NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

APPENDIX I

DIRECT ECONOMIC IMPACTS OF CONSTRUCTION/DEVELOPMENT

[V.2]

A Report Done for
The Department of Energy
and
The New England States

by

THE MASSACHUSETTS ENERGY OFFICE

Henry Lee
Director

The New England Energy Policy Alternatives Study

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APPENDIX I

DIRECT ECONOMIC IMPACTS OF CONSTRUCTION/DEVELOPMENT

INTRODUCTION

The following sections contain analyses of energy events which would provide new energy supplies to New England. This report considers "traditional" energy sources, e.g. electric generating facilities and development of the Outer Continental Shelf. Other potential energy sources for New England including solar power, wood, and wind will be considered in future reports. Each of these sources has the potential for spanning a regional industry and deserve detailed consideration.

Development of the Outer Continental Shelf could provide more direct access to oil and natural gas supplies. Simulations with the Project Independence Evaluation System (PIES) model, indicates that the introduction of OCS oil supplies will not significantly impact New England's oil prices. Preliminary analyses indicate that a major natural gas find could have a greater impact on the New England energy situation. The report that follows has drawn upon existing studies of OCS development to estimate the direct economic impacts of this event.

The decision of when to build new major electric generating facilities is primarily based upon forecasts of electric demand. Simulations with the New England Macro-economic Energy (NEME) model indicate that electric prices are particularly sensitive to unexpected reductions in electric demand (more so for nuclear plants than coal plants).

The direct impacts of building major generating facilities (coal and nuclear) are presented in the following sections. As with OCS development these have been drawn from independent studies.

The following chart summarizes the economic impacts of constructing these facilities.

Summary of
Construction/Development Impacts

Event	Direct Invest	Direct Jobs	Direct Wage	Total Jobs	Total Wages in Millions	Duration yrs.
OCS High	\$ 3.5 billion	84,000/over 30 yr.	\$ 1350 million	132,503	2,713	30
Med	\$.967 billion	18,025/over 25 yr.	\$ 280 million	33,657	602.8	25
No	\$ 1 million	665/15 yr.	\$ 11 million	1,237	23.8	15
Coal \$83.00	\$ 800 million	3,271/5 yr.	\$ 8.37 million	7,196	18.4	5
Nuke \$83.00	\$ 1 billion	4,043/5 yr.	\$ 10.33 million	8,894	22.72	6

Note: Indirect impacts have been estimated using generalized multipliers. Future efforts will attempt more detailed estimation of these indirect macro-impacts.

ECONOMIC IMPACTS OF OUTER CONTINENTAL SHELF EXPLORATION AND DEVELOPMENT

The purpose of this report is to give an estimate of the economic impacts that will occur in New England as a result of Georges Bank related facilities and activities. The report is divided into seven sections: descriptions of facilities entailed, high, medium, and no-find scenarios, marine terminal and refinery impacts, and finally, local tax impacts. The scenario approach was chosen for two reasons: first, because until extensive exploratory drilling is done, no accurate estimation of the fuel reserves is possible and second, because the extent of on- and off-shore activity and its resultant economic effect on New England is directly proportional to the amount of commercially exploitable fuel reserves found. Each scenario, and the marine terminal and refinery sections as well, will include summaries of: land use, capital investment, timing of all facilities and activities, resident vs. total employment, and employment and wages during construction and operation.

All facts and figures were derived from New England River Basin Commission and Arthur D. Little, Inc. estimates. This report is not a prediction; it is merely an estimation of the possible economic impact that will occur in New England.

Descriptions of Types of Facilities Discussed

Service Bases:

Service bases are the link between on-shore and off-shore activities. The main activity of the service bases is the transfer of materials and workers between onshore and offshore operations by supply and crew boats and helicopters. The service bases will include berthage for supply and crew boats, dock space for loading and unloading; warehouses and open storage areas, a helipad and space to house supervisory and communications personnel.

Marine Terminals

Marine terminals may serve one or more of the following functions: load crude oil received from pipelines from offshore sites for transshipment to other areas with refinery capacity; receive crude oil from pipelines or tankers for delivery by overland pipelines to a nearby refinery; and receive refined petroleum products from tankers or from a refinery for delivery to distributors.

Gas Processing and Treatment Plants

A gas processing plant is designed to serve two purposes: first, to recover valuable liquid hydrocarbons, not removed by normal separation methods, from the raw gas stream before it enters a commercial transmission line, and second, to remove impurities from the gas.

Refinery

A refinery simply takes crude oil and alters the constitution of it, chemically and physically, to produce a variety of petroleum products.

Crude oil arrives at the refinery by pipeline or tanker and is stored. When it enters the production stream, the crude oil may go through as many as four processes to produce different petroleum products: separation, conversion, treatment, and blending. After the oil has been refined it is stored and later distributed.

Drilling Apparatus

Exploratory drilling activity will employ mobile drilling rigs, for obvious reasons. Once exploitable oil and gas reserves are found, platforms will be installed and development drilling will begin. The platforms may serve one or all of the following functions: development of field production operations, and partial processing of oil stream. The wells drilled will eventually be "worked over" to maintain well productivity and pressure. (See high and medium find scenarios.)

Pipe-Coating Yards

Ninety-five percent of all pipe-coating yard land is devoted primarily to storage. The remaining five percent is used for the actual pipecoating, done to prevent corrosion and assure adequate weight for sinkage, and for administrative purposes.

Pipe-coating yards should, if possible, be located on or near a waterway, with access to a railroad or major highway.

High-Find Scenario

Under the high-find scenario, 2.4 billion barrels of oil and 12.5 trillion cubic feet of gas are assumed to be commercially exploitable. According to the United States Geological survey, the probability of a high-find case is 5 percent.

Offshore Activities

Oil and gas exploration on Georges Bank will begin in year one (1978, assuming a 1977 lease sale) and continue for the next 21 years. Peak drilling activity will occur in years 6 through 8 with a total of 144 exploratory wells being drilled. Over the 21 years of exploratory drilling, a total of 548 wells will be drilled, with 70 percent of these wells drilled in the first 10 years of OCS development.

Table 1 shows the number of exploratory wells drilled annually.

Development

Oil and gas will first be discovered in year two. Platform installation will commence in year five. Table 2 shows the number of platforms installed annually.

A total of 69 platforms will be installed on the Georges Bank under the high-find scenario. Each platform will be equipped with two drilling rigs, each capable of drilling 4 development wells annually. A total of 24 wells will be drilled from each platform, 20 of which will be productive. Table 1 shows the number of development wells drilled annually.

Transportation of Oil and Gas

Pipelines or tankers and barges are the two methods currently available. Because of the estimated quantity and production rate under the high-find scenario, it is assumed that pipelines will be the method used for transportation of the oil and gas. A total of six pipelines will be installed, two for oil and four for gas, totalling over 1,300 miles, plus an additional 700 miles of gathering lines. Pipeline installation will begin in year 7 and carry through year 15.

Production and Workover

Production of oil and gas will begin in year nine (1985, assuming a 1977 lease sale), and continue for the next 23 years. Peak production of oil will occur during years 19 through 26, with 440,000 barrels per day being extracted. An average of 286,000 barrels per day will be produced over the 24-year period.

Peak gas production will occur during years 18 through 23, with more than 3 billion cubic feet per day produced. Average gas production will be slightly below 1.5 billion cubic feet per day.

After a well has been in operation for a few years, it is "worked over" in order to maintain pressure and constant oil and gas flow. "Workover" will occur during years 14-29, with an average of 173 wells being worked over annually. Because of the great demand for materials during the workover period, service base activity will increase considerably as more offshore deliveries are made. Table 1 shows the number of wells worked over annually.

Onshore Activities

Since the level of onshore activity is directly related to the level of offshore activity, initial onshore activity will be minimal, as only exploration will be occurring. As oil and gas are found, on- and offshore activity will increase rapidly.

Service bases will be small and temporary, at first, but as discoveries are made, permanent service bases as well as ancillary industries (gas lift, well equipment, and logging companies) will be established.

During year 2 (1979, assuming a 1977 lease sale), construction of a platform fabrication yard will begin. By year 3, construction will end and operation will begin. Although it is not required that a platform

fabrication yard be established in the region, it is assumed that because of the level of the entire OCS development (Baltimore Canyon, Southeast Georgia Embayment and Georges Bank), a number of these facilities will be located on the East Coast, one of which will be in New England.

As the development stages near the production stage, formulation of transportation plans will begin. Under the high-find scenario, it is assumed that 6 pipelines will be installed, 2 for oil and 4 for gas. The use of pipelines will create the need for a pipe-coating yard and a service base to support installation activity. It is assumed that the natural gas found on Georges Bank will be rich enough in such valuable products as propane and butane to justify the construction of 4 gas processing plants.

Although refinery impacts have been treated as a separate section, they have been included in this analysis to help illustrate the full range of OCS onshore-related activity. It is important to remember, however, that the decision to site a refinery in the New England region will depend more on the long-range demand for refined petroleum products than on the discovery of offshore oil.

Associated with the refinery will be a marine terminal/surge storage facility designed to receive crude oil from tankers as well as store Georges Bank crude oil during peak production periods for transshipment.

With the exception of one gas processing plant, all facilities will be constructed and in operation by the end of year 15. Thereafter, production and workover activities will predominate offshore, with the operation of service bases, gas processing plants and the refinery being the principal onshore activities. During years 15 through 30, on- and offshore activity will gradually taper off.

Table 4 shows the timing for construction and operation for all required facilities under the high find scenario.

Table 5 summarizes the number and kinds of onshore facilities established under the high find scenario.

Under the high find scenario, an estimated 2700 acres will be used by OCS-related facilities. Some 38 percent will be needed for the refinery. The greatest demand for land will occur during the first 15 years of activity and then taper off gradually over the next 15 years. Table 7 shows land use under the high-find scenario.

Capital Investment

Under the high-find scenario, nearly \$3.5 billion will be in on-shore facilities and pipelines. The refinery (20%) and pipelines (69%) account for nearly 90 percent of the total investment.

Nearly 70 percent of the total capital investment will occur during the first ten years of OCS-related activity. Of this total, 62 percent will be invested in pipelines and 30 percent invested in the refinery. Table 8 shows the yearly capital investments made under the high-find scenario.

After year 17, little capital investment is foreseen as all production, transportation, storage, and processing facilities will be constructed and in operation. Table 3 shows the capital investments that will be made under the high-find scenario.

Local vs. Total Employment: Construction

Under the high find scenario, 8 major facilities will be constructed, 6 gas processing plants, one refinery, and one marine terminal/surge storage facility. The refinery and the marine terminal, however, will be discussed later in this report, so for the moment only the construction of the gas processing plants will be discussed.

The six gas processing plants will be constructed in years 8, 11, 12, 14, 15, and 16, respectively. Average employment during the six years of construction will be 267, of which 134 (50%) will be members of the local labor force. Table 4 shows the average local and total employment for various facilities potentially required for a high find scenario.

Local vs. Total Employment: Operation

Service Bases

Under the high-find scenario, it is assumed that when permanent service bases are established in year two (1979, assuming a 1977 lease sale), 50 percent of the jobs created will be filled by members of the local labor force. The percentage of local employment will steadily increase, and by year 18, local workers will represent 80 percent of the total service base employment. For the remaining 13 years of service base operations, the percentage of local employment vs total employment will remain at 80 percent. This figure is misleading, however, because even though the percentage of local vs total labor will increase steadily, the actual number of local workers employed will steadily decrease after year ten, as development activity slows.

Platform Fabrication Yard

Under the high-find scenario, it is assumed that a platform fabrication yard will be located in New England, serving not only New England, but the Baltimore Canyon and possibly the Southeast Georgia Embayment.

The platform fabrication yard would begin operating in year 4 and continue through year 13. Average employment will be 2,025, of which 1,620 (75%) will be members of the local work force.

The platform fabrication yard will build approximately 69 platforms for Georges Bank development, and an additional 23 for other OCS developments.

Platform Installation

Platform installation will be carried out over an eight-year period (years 7-14). Average annual employment will be 540, of which 108 (20%) will be members of the local labor force.

Pipe-Coating Yard

The pipe-coating yard will begin operating in year 8 and will continue to do so until year 14. The average annual employment during those years will be 143, of which 129 (90%) will be local workers.

Gas Processing Plants

The six gas processing plants will have an aggregated operation time of 20 years (years 10-29). The combined average annual employment for the six plants will be 84, of which 50 (60%) will be resident workers. Table 4 also shows the average and total employment for various facilities under the high find scenario.

Direct Employment

Over the entire 30-year development period, under the high-find scenario, direct employment, both onshore and offshore, will average nearly 2,800 workers, of which 1,800 (57%) will be hired locally.

The greatest number of jobs will be in years 7 and 8, with a total of 7,600 and 9,500, respectively. During both years, 3,000 workers will be employed at the platform fabrication yard and 2,000 workers will be involved in refinery construction. Offshore employment for these years will be 1,380 and 2,300, respectively. The workers employed offshore will be involved mainly in platform and pipeline installation.

Once refinery construction is completed in year 8, employment will drop 34 percent. After year 13, the level of direct employment will decline rapidly with the end of both platform fabrication and platform and pipeline installation. From a high of over 9,500 in year 8, employment will decline to 5,800 in year 13 and 2,000 in year 15, a total seven-year drop of nearly 80 percent. After year 14, offshore employment will cease and onshore employment will steadily decline. Table 5 shows direct employment under the high find scenario.

Wages

The wages generated under the high-find scenario will follow the same pattern as employment, peaking in years 6 through 13, and ranging from \$95 million to over \$150 million annually during that period.

Of the average annual total of \$45 million in wages, \$40 million will be paid to onshore employees. Fifteen percent of this will be paid to the construction workers of the gas processing plants, the refinery and the marine terminal. Over 30 percent of the total average annual wages will be paid to platform fabrication yard employees and 35% will be earned by service base employees. Most of the remainder will be paid to operations workers at the other onshore facilities, gas processing plants, the refinery, etc. Table 5 shows the wages generated by the Georges Bank development.

The first fifteen years of Georges Bank activity under the high-find scenario will be the most active ones. During this period, on- and offshore activity will be the greatest, with the construction of gas plants platforms, pipelines, the marine terminal and the refinery underway. Service base activity will peak as a result of the extent of exploratory and developmental drilling.

As the construction/development ends, the major offshore activity will change to production and the major onshore to processing and distributing.

Table 1
High Find Scenario
Offshore Activities

Year after first lease sale	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
Total exploratory wells drilled	28	36	44	44	48	48	48	44	40	40	32	24	16	12	12	8	8	4	4	4	4

Development Wells Drilled	24	56	120	176	224	240	240	224	192	112	48
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Total Platforms Installed	3	4	8	10	10	10	10	8	6
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Year after first lease sale	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th
Number of wells worked over	7	14	41	86	149	213	279	328	348	346	315	241	173	119	71	30

SOURCE: NERBC, 1976

TABLE 2

Onshore Facilities and Activities High Find Scenario

YEAR AFTER FIRST LEASE SALE

Facilities

1 2 3 4 5 6 7 8 9 10 15 20 25 30

~~Service~~ Bases

Temporary 4-5

Permanent 10-20

Platform Fabrication Yard

Platform Installation

Offshore operations

Service bases 2

Pipeline Installation

Offshore operations

Service bases 2

Landfall/shore terminal 2

Pipe Coating Yards

Gas Processing and
Treatment PlantsMarine Terminal/Surge
Storage Facility

Refinery

Construction

Key: Operation of facility to serve Georges Bank development

Operation of facility to serve other OCS regions

Source: NERBC, 1976

TABLE 3
Capital Investments

10-20	temporary and permanent service bases	\$	23.7
2	platform installation service bases		1.0
2	pipeline installation service bases		1.0
1	platform fabrication yard		50.0
2	pipe-coating yards		20.0
6	pipelines and landfalls		\$2,414.0
2	crude oil pipeline shore terminal pumping stations		
6	gas processing and treatment plants		266.0
1	marine terminal/surge storage facility		25.0
1	refinery		690.0
TOTAL			\$3,495.7

SOURCE: NERBC, 1976

TABLE 3
Timing of Capital Investment
High Find Scenario

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Yearly investment (In millions)	.7	56	12	6	230	386	1045	205	357.5	325	335	335	115	40	26	20

TOTAL APPROX. 3.5 Billion

TABLE 4
High Find Scenario

Employment and Wages by Facility

EMPLOYMENT

<u>Average</u>		<u>Peak</u>		
<u>Local</u>	<u>Total</u>	<u>Local</u>	<u>Total</u>	
636	871	1,285	1,736	permanent service bases
1,620	2,025	2,400	3,000	platform fabrication yard
261	1,043	340	1,360	platform installation (offshore)
59	86	85	118	platform installation service base
108	540	185	923	pipeline construction (offshore)
40	50	40	50	landfall construction
25	36	40	61	pipeline construction service base
129	143	217	241	pipecoating yards
50	84	89	149	gas processing plants operation
133	267	200	400	construction
25	35	25	35	marine terminal operation
80	400	80	400	construction
287	410	287	410	refinery operation
1,400	2,000	1,400	2,000	construction

WAGES (in millions)

<u>Average</u>		
<u>Local</u>	<u>Total</u>	
\$10.9	\$14.8	permanent service bases
30.8	38.5	platform fabrication yard
4.7	18.8	platform installation (offshore)
1.0	1.5	platform installation service base
0.8	3.9	pipeline construction (offshore)
0.05	0.1	landfall construction
0.4	0.6	pipeline construction service base
2.3	2.6	pipecoating yards
0.8	1.3	gas processing plants operation
2.7	5.3	construction
0.4	0.6	marine terminal operation
1.6	8.0	construction
4.3	6.2	refinery operation
28.0	40.0	construction

TABLE 5

High Find Scenario

Total Employment and Wages

Year after first lease sale	Direct onshore	Wage million of \$ onshore	Direct Offshore	Millions offshore Wages	Total Employment	Total Wages
1	0	0	0	0	0	0
2	237	4.0	0	0	426	8.0
3	317	5.4	0	0	570	10.8
4	886	16.1	0	0	1,594	32.2
5	1,915	35.6	414	7.5	4,109	84.3
6	4,831	92.7	544	9.8	9,565	202.6
7	6,219	118.7	1,380	21.8	13,402	275.5
8	7,246	130.4	2,283	32.1	16,696	316.9
9	4,632	82.5	1,652	27.4	10,980	213.0
10	4,660	81.5	1,991	28.5	11,574	212.9
11	4,567	74.7	1,991	28.5	11,407	199.3
12	4,729	75.0	1,719	24.3	11,262	192.5
13	4,359	75.3	1,447	18.5	10,161	183.0
14	2,477	36.1	292	2.2	4,926	76.1
15	2,008	29.1	0	0	3,614	58.2
16	1,809	25.7	0	0	3,256	51.4
17	1,473	23.4	0	0	2,651	46.8
18	1,568	25.0	0	0	2,822	50.0
19	1,606	25.6	0	0	2,891	51.2
20	1,685	27.0	0	0	3,033	54.0
21	1,732	27.8	0	0	3,118	55.6
22	1,691	27.2	0	0	3,044	54.4
23	1,646	26.4	0	0	2,963	52.8
24	1,529	24.5	0	0	2,752	49.0
25	1,312	20.8	0	0	2,362	41.6
26	1,140	17.9	0	0	2,052	35.8
27	993	15.4	0	0	1,787	30.8
28	789	12.3	0	0	1,420	24.6
29	658	10.1	0	0	1,184	20.2
30	549	8.2	0	0	988	16.4
31	497	7.3	0	0	894	14.6

Note: Totals include indirect impacts calculated using generalized multipliers direct to total

	Onshore	Offshore
Employment	1.8	1.6
Wages	2	1.75

Medium-Find Scenario

Under the medium-find scenario, 900 million barrels and 4.2 trillion cubic feet of natural gas are assumed to be commercially exploitable. These quantities represent the statistical means of the United States Geological Survey's 1975 Georges Bank resource estimates.

Off Shore Activity

Exploration. Oil and gas exploration on Georges Bank will begin in year 2 (1979, assuming a 1977 lease sale), and continue for the next 21 years. A total of 548 wells will be drilled, 420 of which will be drilled in the first ten years of exploration.

Table 6 shows the number of exploratory wells drilled yearly.

Development. Oil and gas will be discovered in year 3, which will cause initiation of development planning activities. The first platform will be installed in year 6, with a total of 25 platforms installed over the five-year period. Table 6 shows annual platform installation activities.

Each platform will be equipped with two development drilling rigs, each capable of drilling four development wells annually. Table 3 shows the number of development wells drilled annually under the medium-find scenario.

Transportation of Oil and Gas. Production of oil and gas will begin in year 10. Because of the high cost and environmental dangers of tanker transportation of natural gas, two pipelines will be installed, one in year 9 and one in year 11.

Crude oil, on the other hand, will be transported by tankers or barges to existing East Coast refineries, for the reason that the estimated crude oil production rate is not great enough to justify a crude oil pipeline. Offshore storage and loading facilities will be constructed as an alternative.

Production and Workover

Crude oil and gas production will begin in year 10 and will continue through year 30. Under the medium-find scenario, peak production of oil will be just over 166,000 barrels per day from the 16th through the 25th years. Average crude oil production will be just under 125,000 barrels per day. Natural gas production of oil will peak at more than one billion cubic feet per day during years 14-20. Average natural gas production will slightly exceed 560 million cubic feet per day.

After a well has been in operation for a few years, it is "worked over" to maintain pressure and constant oil and gas flow. "Workover" will occur in years 16-27. Because of the great demand for materials during the workover period, service base activity will increase as more offshore deliveries are made. Table 6 shows the number of wells worked over annually.

Onshore Facilities

Since the level of onshore activity is directly related to the level of offshore activity, initial onshore activity will be minimal, as only exploration will be occurring. As oil and gas are found on- and offshore, activity will increase proportionately.

Service bases will be small and temporary at first, but as discoveries are made, permanent service bases as well as ancillary industries (gas lift, well equipment and logging companies) will be established in New England.

As the development stage nears the production stage, formulation of transportation plans will begin. Pipelines will transport the natural gas and tankers or barges will be used to transport the crude oil.

The use of pipelines will create the need for a pipe-coating yard and a base to support installation. Under the medium-find scenario, it is assumed that the natural gas will be rich enough in valuable products such as propane and butane to justify the construction of two gas processing plants.

Timing of All Required Facilities Under the Medium Find Scenario

The first 12 years following the initial lease sale construction of service bases, gas plants and a pipe coating yard will take place onshore. During years 6-12, platforms and pipelines will be installed offshore. Construction of the first gas processing plant will begin in year 8 and will end at the beginning of year 9. Operation will last for 16 years. Construction of the second gas processing plant will begin in year 10 and end in year 11, with its operation lasting for 18 years. Table 7 shows the number and timing of construction and operation of all required facilities under the medium-find scenario.

Land Use

An estimated 562 acres of land will be used for onshore facilities under the medium find scenario with over 50% of that land being used by the various service bases.

An estimated total of \$966.7 million will be invested in pipelines and onshore facilities under the medium find scenario. Table 8 shows the timing and total capital investment for these facilities.

Nearly 90 percent of capital used will be invested in the installation of natural gas pipelines and crude oil gathering lines. How the remaining 10% will be invested will depend upon the amount of land alteration required and how much of the improvements for roads, sewers and water supplies will be paid for by the communities in which the facilities will be established.

Local vs Total Employment: Construction

Gas Processing Plants. The only major construction done under the medium find scenario will be the building of two gas processing plants. The first such plant will be constructed in year 9, with the employment for that year being 225, of which 113 (50%) will be workers from the existing local labor force. The second gas processing plant will be constructed in year 11 and will employ a total of 300 workers, of which 130 (43%) will be resident workers.

Direct Employment

Under the medium find scenario, an average of 721 workers will be employed over the 25-year development period, 400 of which will be hired from the local labor force. Peak employment will occur in year 9 (1985, assuming a 1977 lease sale), when 2,900 workers will be employed. Local and total employment is shown in Table 9.

Local Employment vs Total Employment: Service Bases

Under the medium find scenario, it is assumed that when service bases are established in year 2 (1979, assuming a 1977 lease sale), 50% of the jobs created will be filled by members of the local labor force. The percentage of local employment will steadily increase until year 18, when the local workers will represent 80% of the total service base employment. For the remaining 13 years of service base operations, the percentage of local employment vs total employment will remain at 80%. This figure is misleading, however, because even though the percentage of local vs total labor will increase steadily, the actual number of local workers employed will steadily decrease after year 10, as development activity slows. The service base employment will average 426 annually, of which 305 will be drawn from the existing labor force. Local and total employment for service bases and the following facilities is shown in Table 9. Total end yearly onshore and offshore employment and wages is given in Table 10.

Platform Installation

Platform installation will begin in year 6 and will carry through to year 12. Average yearly employment will be 592, of which 148 (25%) will be local workers.

Pipeline Installation

Pipeline installation will begin in year 8 and run through year 12. Average employment will total 294, of which 38 (13%) of the workers will be from the local employment force.

Pipe-Coating Yards

Pipe-coating yard activity will begin in year 9 and last for four years. The average annual employment level will be 88, of which 79 (90%) will be local workers.

Gas Processing Plants

Operation of the two gas processing plants will begin in years 10 and 12, respectively; both will cease operating in year 29 (2006, assuming a 1977 lease sale). Combined average annual employment for the two facilities will be 46, of which 27 (58%) will be local workers. Fifty-three percent will be involved in offshore platform and pipeline installation activity, while 1,006 (35%) will be employed at the service bases. Nearly all remaining workers will be involved in pipe coating operations or gas processing plant construction.

After year 11, direct employment will decline rapidly from 2,294 to 537 in two years. During the next 16 years the employment level will average 360 workers annually.

Direct Wages

Wages, as well as employment, will peak during years 8 through 11. Total wages will average \$11.2 million over the 28-year development period, with an average \$8.6 million being paid to onshore employees and an average \$2.6 million paid to offshore employees; \$7.5 million dollars of the \$8.6 million paid to onshore employees will go to service base employees and \$1 million dollars to gas processing plant personnel.

Conclusion

The first 10 years of Georges Bank activity under the medium-find scenario will be the most active ones. During this period on- and off-shore activity will be the greatest, with the construction of gas plants and pipelines underway. Service base activity will peak as a result of the extent of exploratory and developmental drilling.

In the construction/development phase, the major offshore activity will change to production and the major onshore activity to processing and distributing. Onshore activity will gradually taper off during the last 15 years of production.

TABLE 6

Medium Find Scenario
Off shore Activities

EXPLORATORY WELLS DRILLED YEARLY
MEDIUM FIND SCENARIO

Year After First Lease Sale	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
Total Number of Wells Drilled	28	36	44	44	48	48	48	44	40	40	32	24	16	12	12	8	8	4	4	4	4

PLATFORM INSTALLATION SCHEDULE
MEDIUM FIND SCENARIO

Year After First Lease Sale	6th	7th	8th	9th	10th	11th
Total Platforms Installed	3	2	9	7	1	3

Year After First Lease Sale	7th	8th	9th	10th	11th	12th	13th	14th
Development Wells Drilled	24	40	112	144	136	88	32	24

WORKOVER ACTIVITY
MEDIUM FIND SCENARIO

Year After First Lease Sale	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th
Number of Wells Worked Over	14	56	54	105	169	142	133	122	103	63	21	18

SOURCE: NERBC, 1976

TABLE 7
TIMING OF FACILITIES AND ACTIVITIES
MEDIUM FIND SCENARIO

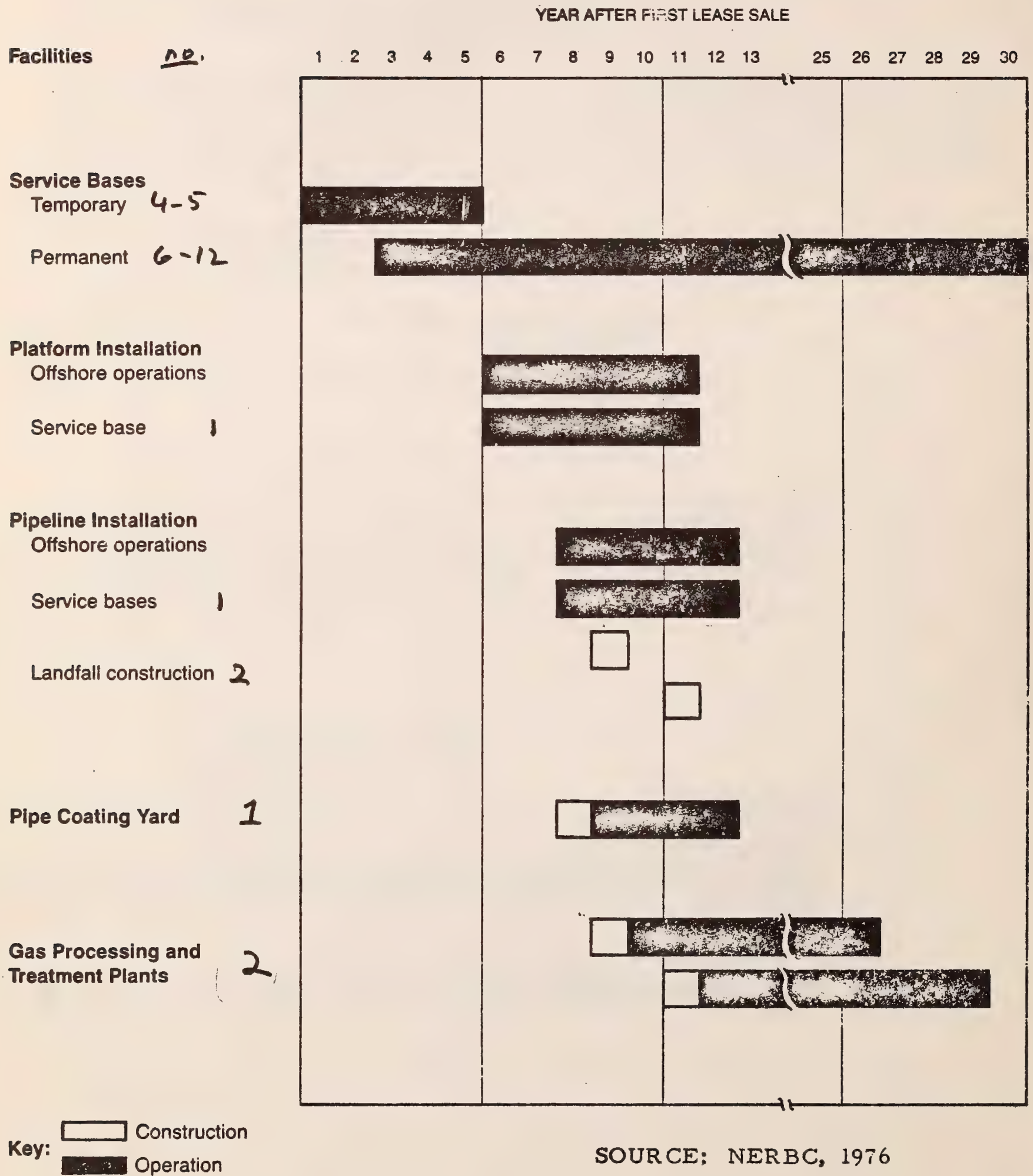


TABLE 8

TIMING OF CAPITAL INVESTMENT

Medium Find Scenario

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Yearly Capital Investment (\$ in Millions)	0	.5	.2	1	2	7	0	60.5	35.05	177.5	335	35	969.2

CAPITAL INVESTMENTS (in \$ millions)
MEDIUM FIND SCENARIO

6-12	permanent service bases.....	\$ 14.7
1	platform installation service base.....	\$ 1
1	pipeline installation service base.....	\$ 1
1	pipe coating yard.....	\$ 10
2	pipelines and landfalls.....	\$850
2	gas processing and treatment plants	\$ 90
TOTAL.....		\$966.7
SOURCE: NERBC, 1976.		

TABLE 9

YEARLY EMPLOYMENT

Medium Find Scenario

<u>Average</u>		<u>Peak</u>		
<u>Total</u>	<u>Local</u>	<u>Total</u>	<u>Local</u>	
426	305	1,076	753	Permanent Service Bases
592	148	1,278	320	Platform Installation
50	34	104	69	Platform Installation Service Bases
294	38	507	101	Pipeline Installation
28	20	38	26	Pipeline Installation Service Base
88	79	121	109	Pipecoating Yard
263	122	300	130	Gas Processing Plants: Construction
46	27	52	31	Operation

YEARLY WAGES (in \$ millions)

Medium Find Scenario

<u>Total</u>	<u>Average</u>	<u>Local</u>	
7.2		5.1	Service Bases
10.6		2.6	Platform Installation
5.2		3.4	Platform Installation Service Base
1.8		.36	Pipeline Installation
.16		.12	Pipeline Installation Service Base
1.7		1.5	Pipecoating Yard
5.3		2.7	Gas Processing Plants: Construction
.7		.4	Operation

TABLE 10

TOTAL DIRECT EMPLOYMENT AND WAGES
FOR SELECTED OCS-RELATED FACILITIES (MILLION \$)
MEDIUM FIND SCENARIO

Year after first lease sale	Direct onshore	Direct Onshore Wages	Direct offshore	Direct Offshore Wages	Total employment	Total Wage
1	0	0	0		0	0
2	237	4.0	0		427	8.0
3	317	5.4	0		570	10.8
4	386	6.6	0		694	13.2
5	380	6.5	0		684	13.0
6	436	7.4	426	7.7	1,466	28.3
7	502	8.5	284	5.1	1,358	25.9
8	645	10.7	1,503	23.6	3,565	62.7
9	1,352	23.5	1,551	21.0	4,916	83.8
10	1,246	21.1	372	4.9	2,838	50.8
11	1,541	27.1	753	10.1	3,978	71.9
12	958	16.0	230	.6	2,092	33.0
13	537	9.0	0		967	18.0
14	465	7.8	0		837	15.6
15	344	5.8	0		619	11.6
16	359	6.0	0		646	12.0
17	398	6.7	0	0	716	13.4
18	387	6.5	0	0	696	13.0
19	435	7.3	0	0	783	14.6
20	537	9.0	0	0	967	18.0
21	470	7.9	0	0	846	15.8
22	445	7.5	0	0	801	15.0
23	415	7.0	0	0	747	14.0
24	390	6.5	0	0	702	13.0
25	335	5.6	0	0	603	11.2
26	291	4.9	0	0	524	9.8
27	186	3.1	0	0	335	6.2
28	78	1.3	0	0	140	2.6
29	78	1.3	0	0	140	2.6

Note: Totals include indirect impacts calculated using generalized multipliers
direct to total

	Onshore	Offshore
Employment	1.8	1.6
Wages	2	1.75

NO FIND

Under the no-find scenario, no commercially exploitable reserves are found. It is assumed that exploratory activity will last for five years and then cease as small reserves, "teasers", that are not economically viable are found.

Offshore Activity

Offshore activity will be limited to exploration. Exploration will begin in year 2 (1979, assuming a 1977 lease sale) with seven exploratory rigs operating. Over the next four years, offshore activity will decrease yearly. By year 6, only one rig will be operating. Table 11 summarizes exploratory rig activity.

Onshore Facilities

It is assumed that temporary service bases will be the only facilities established in New England. (Certain ancillary industries will settle in the region but their impact will be transient.) It is estimated that 4-5 temporary service bases will be established to support exploration activity.

Land Use

The number of variables will determine the exact amount of land needed, such as: number of companies involved in exploration, number of rigs each service base supports, and siting of service bases from rigs. It is assumed, however, that 75 acres will be needed for the service bases.

Capital Investment

Location, numbers of companies involved, and certain other factors will determine the exact amount of capital investment involved under the no-find scenario. These factors will not be known until after the lease sales, but a capital investment of \$1 million has been estimated.

Employment and Wages

Peak employment will occur in the first year, with 237 jobs created, yielding an annual total of over \$4 million in wages. Half of these jobs will be filled by New England residents.

For the next 4 years, employment will decline, and by the end of year 6 all on and offshore activities will have ceased. Under the no-find scenario, the average employment for the five-year period will be 133 workers with over \$2 million in wages paid annually. Total wages paid for the period will be \$11 million.

Conclusion

Under the no-find scenario, on- and offshore activity will be considerably less than that of the high- and medium-find cases. Direct impacts will be minimal and will only last for five years. Seventy-five

acres of land will be used, \$1 million will be invested, and employment and wages will average 133 and \$2.3 million, respectively.

TABLE 11

Exploratory Rig Activity

Year after first lease sale	2nd	3rd	4th	5th	6th
Exploratory Rig Operating	7	5	4	2	1

Refinery

Under the high-find scenario, it is assumed that a refinery will be built in New England. The refinery, however, will be constructed more for the reason of long-term demand than for the immediate oil discoveries on Georges Bank. The final decision to locate a refinery in the region will come after close scrutiny by industry and public officials on the economic and environmental impact likely to be felt in New England.

Number of Facilities

Under the high-find scenario, one refinery is expected to be built. The refinery will have a high fuel product mix, with the following output:

Gasoline	33%
Kerosene/jet fuel	4%
Distillate fuel oil	27%
Residual fuel oil	36%

Such a product mix is in accord with New England's present and future demand for petroleum products.

Construction: Time and Employment

Construction will begin in year 6 (1983, assuming a 1977 lease sale), and will last for 3 years. Average annual employment will be 2,000, of which 1,400 (70%) will be drawn from the existing labor force. The average annual salary will be \$20,000, with the total amount of wages generated over the 3-year construction time being \$120 million.

Land Use

The 250,000 barrel-per-day high fuel oil mix refinery will occupy a 1,000 acre site.

Capital Investment

A total capital investment of \$690 million will be required to establish the refinery.

Employment: Operations

Annual employment will be 410. Over a 19-year period, the workers will earn \$6 million annually and more than \$100 million total. Over \$70 million of this sum will be paid to local workers.

Power and Energy Requirements

It is assumed that the refinery will require 1.5 million kilowatt hours and 20,000 barrels of oil daily.

Refinery Throughout

During years 9-13 and 28-31, Georges Bank crude oil will not be sufficient to fill the refinery's capacity; during these years, supplementary imported oil will be needed.

Conclusion

Refinery construction will begin in year 6 (1983, assuming a 1977 lease sale) and will last for 3 years. Employment over those years will average 2,000 workers annually, of which 1,400 (70%) will be local workers. Land use and capital investment will be 1,000 acres and \$690 million, respectively. During operation the refinery will employ 410 workers annually.

Marine Terminal Impact

Under the high-find scenario, it is assumed that one marine terminal will be constructed in New England. The terminal will serve two purposes: first, it will be used to store imported oil during years 9-13 and 28-31, when Georges Bank oil will not be sufficient to fill the capacity of the refinery, and second, during the peak years of Georges Bank production (years 14-27), when production will surpass the capacity of the refinery; the surplus will be stored at the marine terminal for transshipment to areas with available refinery capacity.

Land Use

The marine terminal will be located on the waterfront and will occupy a 100-acre site.

Capital Investment

The total capital investment will depend largely on the length of the pipeline between the marine terminal and the refinery. The cost of the pipeline could range from as low as \$10 million to as high as \$50 million. For the purposes of this analysis, it is assumed that the cost of the pipeline will be \$12.3 million of the \$25 million total capital investment (1974 dollars).

Construction: Time and Employment

Construction of the marine terminal will take place in years 7 and 8. An annual average of 400 workers will be required during construction, of which 80 (20%) will be hired from the local labor force. The average annual salary of these workers will be \$20,000.

Capacity

The marine terminal will have four 250,000-barrel capacity floating roof storage tanks, one 36,000-barrel storage tank for distillates, and one 45,000-barrel tank for heavy fuel oils, for a total storage capacity of 1,081,000 barrels of oil.

Operations: Employment

Operations employment for the marine terminal will be 35 workers, of which 72% (25 workers) will be local workers. Average annual salaries for these employees will be \$16,000.

Throughout

In years 9-12 and in year 31, oil will be imported and stored at the marine terminal as a result of insufficient Georges Bank production. In years 13 and 27, production will be close to that of refinery capacity, and therefore little oil will be stored in the marine terminal. During years 17-23, production will exceed refinery capacity, making it necessary to transship the surplus. During these years, a major amount of oil will be stored at the marine terminal.

Conclusion

One marine terminal/surge storage facility will be constructed under the high find scenario. Construction will occur in years 7 and 8, employing 400 workers yearly. Of these workers 80 (20%) will be local.

Capital investment will total \$25 million, of which \$12.3 million will be pipeline costs.

The facility will occupy 100 acres of waterfront land.

The marine terminal will have a storage capacity slightly in excess of 1 million barrels.

Thirty-five workers will occupy the terminal at an average annual salary of \$16,000; 80% of the workers will be hired locally.

Taxes

Introduction

This section is not a detailed taxation analysis of the Georges Bank development. It is first, an attempt to show, through case studies, the difficulties that may arise in the determination of the difference between real estate and tangible personal property (i.e., machinery), and second, through the further use of case studies, an attempt to show some of the different effects felt by municipalities during and following the construction of a refinery and gas processing plants. Although none of the following studies involve gas processing plants per se, it is assumed that the construction of such plants will produce some of the same effects that a refinery would, notably, taxation difficulties and municipal service cost effects.

Presently none of the New England states levies a tax on machinery. Massachusetts' corporation excise tax includes a tax on machinery, but in recent years the amount taxable has decreased yearly and by 1983, when the refinery is to be built under the high find scenario, it will most likely have been abolished.

The New England states, at varying times, have decided to exempt machinery from taxation in the hope that the decision in itself would promote the general welfare by inducing new industries to locate here and to foster the expansion and development of our own industries, so that production of goods shall be stimulated, steady employment afforded our citizens, and a large degree of property obtained. Table 7 also shows the average and total employment for various facilities under the high find scenario. If machinery is no longer taxable, then the question that the former being taxable and the latter being exempt. Real estate is conventionally defined as something that is permanently affixed to the land, making transportation of such an object very difficult (i.e., a house, building, etc.). Much of the refinery's machinery, however, is large and cumbersome, such as cooling towers, vessels, storage tanks, furnaces, etc. Because of the size and immobility of such apparatus, they would seem to fall under the classification of real estate. But since they are integral components of the refinery process, they might just as well be deemed machinery.

In the past, such cases have been decided in favor of both the tax payer and the state; as a result, we cannot accurately predict the outcome of such a case. We are obligated, however, to illustrate the confusion and uncertainty which surround the question of real estate vs tangible personal property.

Massachusetts law defines real estate as the land and anything attached to it. This would seemingly include cooling towers, storage tanks, etc. But in a 1971 case, the Supreme Court of Massachusetts ruled that property, regardless of its bulk or attachment to the land, should not be considered real estate for taxation purposes if it is involved in the operation of the manufacturer. The Court also added that the machinery exemption was made in order to stimulate industry and should not be taken narrowly or technically.

In 1974, the Governor of Rhode Island, as part of his economic development plan, had a law passed exempting machinery from taxation. Shortly after this, the Providence JOURNAL wrote: "Whatever other benefits an oil refinery might bring to Rhode Island, the Governor's newly enacted economic development program has taken away most of the impact it would have on total (tax) revenues..... Under the State's revised tax structure only a small fraction of this investment will be taxable."

In New Hampshire, on the other hand, Pervin and Gutz, Inc. concluded that although a large part of machinery in a refinery is not taxable, "the precise line between what is non-taxable machinery and taxable real estate has not been defined in New Hampshire." Pervin and Gutz also concluded that land, buildings and permanent storage tank facilities would be considered real estate and therefore taxable.

In Pennsylvania, this was not the case, however. A Pennsylvania court ruled that refinery storage tanks were machinery, and therefore not taxable, because within them occurs chemical breakdown of the crude oil despite the lack of motion or force.

In an earlier case, on the other hand, the New Jersey State Board of Tax Appeals ruled that because of the permanence of storage tanks, they were taxable real estate.

Because all New England states have abolished their machinery taxation laws, a liberal ruling is possible, should a refinery be built and should the property tax question arise. However, a great deal may depend upon the specific community in which the refinery is to be located.

Municipal Service Costs

Of the four cases listed below, two of four communities benefited from the construction of a refinery, while two suffered some negative effects.

The 23-million-barrels-per-day refinery built in Wrenshall, Minn. in 1953 produced positive effects on the municipality. From the increased tax revenues, the refinery pays over 50% of the school district tax and 80% of Wrenshall's property tax. Wrenshall was able to construct a new school building, town office, and community center. It also improved its street care and landscape maintenance. Since none of the refinery employees settled heavily in any one community, none of the surrounding townships suffered adverse effects.

A refinery built in Benicia, Calif. produced similar tax revenue effects, but Benicia chose to lower the tax rate instead of further improving town facilities. The refinery was assessed at \$44 million, raising the town's tax base from \$8 million to \$52 million. Benicia lowered the tax rate by 21% following construction, thereby reducing tax revenues by \$1.1 million. Benicia did receive \$3.3 million in increased revenues, spending most of it on improving its police force, hiring a city planner, and an increased budget for town recreation facilities.

In the two previous cases all property tax revenues accrued to the municipality which was paying the increased service costs (i.e., new roads, new schools to accomodate additional students, etc.), caused by the refinery. In the following example, however, this was not the case.

The construction of a 47MBD refinery in Mandan, N.D. in 1954 also added much needed economic stability in the form of new jobs and improvements to schools. But because the refinery was located outside the city limits, the only direct tax revenues Mandan received were through the school district. During and immediately following construction, schools were overcrowded and several access roads to the refinery were built at the city's expense.

The two refineries constructed in Ferndale, Wash., a 70MBD refinery in 1953 and a 100MBD refinery in 1972, produced similar results. Access roads were built, new teachers were hired and temporary classrooms were set up as a result of overcrowded schools, municipal services and facilities were overloaded, and because of the time differential between the needed improvements and the accrual of tax revenues, Arco loaned Ferndale money in lieu of future tax payments.

Although Ferndale received money from the two refineries through the school district, they did not receive any other tax revenues to pay for the increased municipal service costs, because the refineries were located outside the city limits.

The greatest problem in all the above examples was the time differential between the needed municipal service improvements and the receipt of the tax revenues from the refinery. Agreements similar to the one between Arco and Ferndale are common today and in general such agreements reduce the economic pressure on the municipality during and immediately following construction.

DIRECT ECONOMIC IMPACTS OF COAL PLANT CONSTRUCTION

Coal-fired electric plants have been suggested as alternative generating source to nuclear plants. Coal plants have also been suggested in energy alternative which would have early retirement of oil-fired base load plants. This report will consider the direct economic impacts of a coal-fired base-load plant. These direct impacts will include the investment required for the plant, the number of jobs created during the construction and operation phases, and the estimated cost of electricity, from the plant. The report will not debate the cost question of a coal plant vs. a nuclear plant.

At the moment, there is only one coal-fired baseload plant planned for addition to the New England Power Pool. This is the Sears Island plant in Maine. Recent estimates for coal-fired baseload plants have concentrated on the 800-1000 MW size range. We shall estimate impacts for an 800 MW plant.

Investment

Estimates of the capital cost of coal-fired plants tend to fall in the \$600-700/Kw range for a plant coming on-line in the mid-eighties (83-85 in nominal dollars). A 1975 study by Arthur D. Little and S.M. Stoller estimated that an 800 MW plant coming on-line in 1983 would cost \$697/KW (\$1983). This compares with the FEA 1974 estimate of \$380/KW (\$1974), with a long-run inflation rate in the 5-6% range. Total capital cost for an 800 MW plant would fall in the \$480-560 million range (1983\$, - \$285 \$333. million '74\$). Of this total, approximately \$1 million is for land acquisition, and \$160-190 million for direct and indirect labor costs (includes engineering and contractual services).

As much as 20% of the capital cost of the plant is devoted to pollution control devices. The cost of flue gas desulphurization devices has been estimated to cost \$150-200/KW 1983\$ (or \$65-100 1975\$). FEA's estimate for their 800 MW plant was \$92/KW 1974\$. Clearly the capital cost of a coal plant could change considerably with alternative pollution control systems. Two alternatives which have been suggested are the use of tall stacks and fluidized-bed combustion systems. The tall stacks option would involve coastal siting of plants and would require a change in pollution control legislation to use ambient air-quality criteria. The fluidized-bed system is an alternative form of sulphur emission control utilizing advanced combustion techniques. This form of emission control not only reduces the cost of pollution control systems but significantly improves the efficiency of the generation process.

Coal Plant Capital Costs

	Plant Size MW	Operation begins	Pollution control \$/KW(nominal)	\$/KW (nominal)	\$/KW (1974\$)
ADL/Stoller	800	83	150	697	\$415
FEA	800	85	170	704	\$380
Herding ¹ (Concept)	1000	85	126	636	\$342

As with Nuclear plants, the impact of this investment on the region's economy depends on the extent to which it remains within the region. That is, the extent to which suppliers of the major components are located in New England. Accurate estimates of these impacts can only be determined after specific suppliers have been identified for a particular plant. However, as in the case of Nuclear plants we expect a relatively small proportion of this investment to flow to New England business.

Employment

While major generating facilities do create a substantial number of jobs during their construction period, recent experience with generating plants in New England indicates that the local impact of these plants is minimal. Generally, the skills required for power plant construction must be drawn from a larger labor market area, usually a nearby urban center.

1. Unpublished thesis using NRC's "Concept" model for estimating power plant costs.

It is estimated that construction of a 800 MW coal-fired plant will last approximately 5 years. The expected construction employment is given in the following table:

Craft	Coal-Fired Plant	
	Thousands Man Hours	Percent of Total
Pipe/Steam Fitters	1,220	17.9
Laborers	970	14.2
Electricians	825	12.1
Carpenters	475	7.0
Ironworkers	640	9.5
Operating Engineers	535	7.8
Boilermakers	1,270	18.7
Teamsters	185	2.7
Insulators	240	3.6
Millwrights	150	2.2
Painters	90	1.3
Sheetmetal Workers	130	1.9
Concrete Finishers	75	1.1
Totals	6,805	100.0

Source - Atomic Energy Commission (1972?)

Based upon an estimated average construction wage of \$10.50/hr., 1974\$, the total construction payroll for the five years would be \$50.043 million 1974\$ (\$92.83 million. 1985\$)

The relatively permanent employment created by the coal power plant's operating staff is likely to have a more direct impact on the local area. However, the number of jobs created for operation and maintenance of the plant is probably not large enough to have any detrimental effects on the local community. ✓

O & M Employment for 800 MW Coal Plant (man years)

Supervision	16
Operators	40
Maintenance Men	37
Chemical Technicians	1
Fuel Systems Specialists	8
Clerks, Laborers, Guard, Others	18
Total	120
Total Man years/MW	157

Source FEA - Interagency Task Force on Facilities Report 1974.

The annual payroll for this operation and maintenance staff is estimated to be \$3 million (\$12.50/hr) 1974\$ (\$5.56 million 1985\$).

Cost of Power

As in the case of nuclear plants, the cost of power from a coal plant is sensitive to the capacity factor of the plant. Coal plants are not as sensitive to this variable as nuclear plants due to their lower capital cost per KW. Capital cost are typically 50% of power costs for a coal plant vs. 79% for a nuclear plant. The cost of coal does have a significant effect on the cost of power.

FEA projects an average coal price to utilities of \$33.50/ton for low sulfur and \$26.82 for high sulfur ('75\$) Arthur D. Little estimates delivered coal costs to be \$55.20 ('85) for Virginia coal and \$48.00 ('85\$) for Wyoming coal. (\$32.85 and \$28.56 in '75\$ respectively). ADL 1983 estimates are \$50.65 for Virginia coal and \$43.25 for Wyoming coal.

Electric Generating cost for 1983 for an 800 MW coal plant costing \$640 million (\$800/KW) 1983\$, operating at a 75% capacity factor with annual fixed charge rate of 18% are as follows for various coal prices.

25 MMBTU/ton	1983 coal price (\$/ton)	Levelized Generating cost (mills/Kwh)
	\$35.00	41.3
	\$41.01	45.0
	\$47.90	48.0
	\$55.78	51.5

DIRECT ECONOMIC IMPACTS OF NUCLEAR PLANT CONSTRUCTION

Nuclear plants are projected to play an increasingly important role in New England's electric generating system. Nuclear power is projected to become the major generating source by 1990 growing from 21% of capacity to 44%. This domination of the electric system by nuclear plants requires the addition of 9324 MW of nuclear capacity. 7024 MW of this capacity is to be added by 1985, equivalent to the additions used for the "Base" case in this study. The New England Power Pool's forecast and authorized additions as of Jan. 1978 are significantly different. Only two nuclear plants (2388 MW) would be operational by 1985, with one additional plant coming on-line in 1985. These construction plans are closer to the low nuclear simulation of this study which would have one 1194 MW plant coming on line in early 1984.

The investment required is quite substantial, with individual plants costing in excess of \$1 billion. The estimated total investment through 1990 is \$9.3 billion (nominal) with \$7 billion occurring before 1985. Of this total investment, approximately \$96 million will be devoted to construction payrolls, \$72 million by 1985.

Investment

The estimated capital cost of nuclear has varied widely from \$900-\$1200/KW for a plant coming on line in the mid-eighties. The most recent estimates prepared for the Nuclear Regulatory Commission for a hypothetical site are \$499/KW (1976\$) for an 1139 MW plant. The total cost of this plant is \$568.8 million, of which \$133 million is for direct construction payrolls. It has been estimated that a plant in New England would cost 5-6% more than the hypothetical site or \$529/KW (1976\$). (\$856/KW '85\$).

<u>Plant</u>	<u>State</u>	<u>Planned Nuclear Plants</u>		<u>Com (as of) 1 date (1 - 78)</u>
		<u>Size</u>	<u>comp.as of date(1-77)</u>	
Millstone 3	CT	1156	12-82	5-86
Pilgrim 2	MA	1180	10-83	6-85
Seabrook 1	NH	1194	11-81	12-82
Seabrook 2	NH	1194	?-83	12-84
Charlestown 1	RI	1150	11-84	11-86
Charlestown 2	RI	1150	11-84	?
Montague 1	MA	1150	1-86	?
Montague 2	MA	1150	1-88	?
TOTAL		9324		

Employment

There have been a number of studies of the construction impact of nuclear power plants. Fortunately, one of these studies have concentrated on nuclear power plant construction in New England and the Northeast. This section will summarize the conclusion of the paper "The Local Economic Impact of Nuclear Power", by Alice W. Shurcliff, M.I.T. Energy Laboratory.

The construction of a nuclear power plant involves millions of dollars in equipment and labor costs and five to seven years of building activity. As noted by Shurcliff: "Peak employment ranges from about 1,200 for a oneunit plant to 5,400 for a four-unit plant. The number of construction workers on a site increases for the first half of the construction period and then decreases progressively. The mix of required construction skills changes from year to year but in general is characterized by a large proportion of skilled workers, particularly of steamfitters and electricians. The following chart shows the breakdown of labor requirements of a typical plant constructed in Illinois.

1. Nepool Authorized Additions

	Year							
	1	2	3	4	5	6	7	Total
Estimated payroll (Millions of dollars at 1975 levels)	\$4	\$14	\$24	\$38	\$28	\$22	\$4	\$134
Skilled man-years:								
Pipe/steam filters	8	33	155	423	427	293	13	1352
Electricians	2	7	53	353	299	174	8	896
Carpenters	49	174	203	148	62	40	2	678
Iron Workers	25	88	148	111	52	57	3	484
Boilemakers	-	-	85	57	46	22	1	211
Operating engineers	16	46	45	57	37	22	2	225
Truckdrivers	5	19	16	19	10	8	1	78
Insulation workers	-	-	-	-	-	117	13	130
Millwrights	-	-	-	23	34	31	6	94
Cement masons	3	12	19	39	13	13	76	175
Plumbers	-	-	26	26	14	7	1	74
Sheet metal workers	-	-	-	41	22	6	1	70
Unskilled man-years	<u>33</u>	<u>183</u>	<u>228</u>	<u>239</u>	<u>120</u>	<u>92</u>	<u>6</u>	<u>901</u>
Total	141	562	978	1536	1136	882	133	5368

While the number of employees and dollars of payroll associated with nuclear plant construction is substantial, the local employment part of this construction is not necessarily commensurate with the total manpower budget. Nuclear facilities are required to be built in relatively unpopulated areas, and thus the skilled labor pool that is needed is usually not present in the immediate vicinity of the plant. As a result, workers are recruited from nearby urban centers and either commute or, to a lesser extent, relocate to get to work. For the six nuclear sites now in use in New England, only about 15 percent of the workers moved their domiciles to the construction site vicinity. The resultant impact on schools, and public services is thus less than might otherwise be expected. This situation is not typical of the country as a whole, where 20 to 30 percent of the workers have changed their residence to find employment.

Similarly, the local employment rates are only slightly affected by plant construction. The mix of local skills does not always match the skills required by the plant construction.

In summary, employment impacts of nuclear construction in the local community can be expected to be reasonably small because of low local population and improper skill mix. There is every reason to believe, however, that state and regional employment are favorably affected as workers from surrounding urban areas are brought into the construction process.

Analogously, local employment resulting from procurement of plant equipment is likely to be small. Highly specialized machinery and equipment is generally not available from local suppliers and must be brought in from other parts of the region or other parts of the world. It is not possible to predict the breakdown between intra-regional purchases and extra-regional purchases because this varies widely according to plant design and specification and bids on equipment.

Following construction, employment associated with an operating plant falls considerably, as the following chart indicates. As Shurcliff notes: "In addition to operating personnel, certain professionals, necessary to plant operations, but not on a day-to-day basis, are usually on the payroll of the company headquarters. These would include nuclear physicists and engineers who may be assigned temporarily to whichever plant or project requires their expertise, as well as technical and blue-collar personnel who perform the corrective non-routine maintenance occasionally required.

The annual refueling operation is not likely to be a source of significant local employment. Boston Edison Co., for example, contracts for refueling its Pilgrim Plant with General Electric Co., which brings in a group of some 40 shipfitters, riggers, and other specialized personnel, and arranges for help from a subcontractor who employs about 80 shipfitters, riggers, pipefitters, and laborers; these are obtained from union hiring halls nearby.

The logistics of keeping a nuclear plant operating involves frequent replacement of sophisticated instrumentation and equipment and replenishment of industrial gases. Local merchants usually cannot supply these goods in bulk at competitive

prices. The lifeline between the plant and the industrial suppliers consists of trucks which haul the costly - but not bulky - products to the plant.

Tax benefits to local communities, on the other hand, are often substantial. Nuclear power plants require little in the way of public services from localities, but they can contribute greatly to local revenues.

ENERGY CONSERVATION IMPACTS

SUMMARY OF CONSERVATION IMPACTS

These sections describe the potential for energy conservation in the commercial, residential and industrial sectors. Estimating the potential for conservation and its likely cost has been one of the most difficult tasks of this study. The difficulty in making these estimates corresponds to the difficulty in identifying prototypical energy use in the various sectors. Consequently the most direct estimates could be made for the residential sector, followed by the commercial and industrial sectors. Energy Conservation measures are extremely cost effective investments. Further, they are the cheapest available means of offsetting the impact of rising energy prices. Nevertheless, our estimates indicate that only a small portion of this "conservation potential" will be realized. Lack of information regarding appropriate conservation measures remains a continuing obstacle. The first step for government conservation programs is to improve technical information in all three sectors. Further government measures are clearly justified in the residential sector and probably justified in the commercial sector. The condition of New England's industrial real estate may become an obstacle to economic development and its upgrading may require government assistance.

The "Commerical Energy Use Report" identifies reasonably attainable reductions in energy use. While specific estimates of costs are not included, the report identifies those levels of conservation which are economically justified. This information, coupled with estimates of experts in the field, has enabled us to make the estimates of direct impacts shown in the following chart, (methodological details are given in the "Macro Impact" section).

The first commercial case would apply the ASHRAE 90-75 standards to new commercial buildings built between 1979 and 1985. According to Arthur D. Little's report on this standard, reductions in energy use of 40-50% can be achieved with no net increase in building construction costs. We estimate slight increases in direct construction labor. The second case involves standards for new buildings plus economically justified retrofitting of existing buildings. In this case existing building's energy consumption is reduced roughly 20%.

Residential conservation is of extremely high value to the region. Estimating the potential for conservation in the residential sector and costs of appropriate measures was relatively straightforward. Residential conservation programs are extremely successful because less than 20% of the region's housing stock is adequately insulated and weatherized. Consequently, residential conservation is an extremely good investment applicable to a large number of homes. The benefits of residential conservation indicate the need for government programs to insure adequate insulation of New England's housing for all income groups.

Estimating conservation potential for New England manufacturing firms was extremely difficult. As a result, we undertook primary research in this area. First we conducted a survey of New England businesses in an attempt to identify firms' attitudes towards higher energy costs and energy conservation. Important results of the survey were: 1) the ability of New England firms to pass along energy price increases without seriously affecting their competitive position; 2) the general lack of technical knowledge regarding energy conservation measures; and 3) where conservation measures were known, the inability to finance the investment required due to a combination of the cost of capital and the relatively low priority given to energy conservation investments.

Following the survey, we developed a study design to attempt to quantify the potential for industrial conservation in New England and the likely response of New England firms to higher energy prices. Due to a limited budget we selected two detailed industry groups -- furniture manufacturing and metal-working machinery -- which seemed to be important in the New England economy and have some competitive advantage to be gained by conservation programs. A contract for this study was awarded to Harbridge House. This study supports the findings of the survey and indicates higher energy prices, alone, will induce little energy conservation investment. Further, even though many cost justified conservation measures are available, only large firms are likely to adopt these measures.

Summary of Conservation Impacts

Investment Impacts
Cumulative through 1985 in millions '74 \$

Conservation Events (Energy Savings)	Direct Invest	Direct Job	Direct Labor Income	Total Jobs	Total Income
Commercial					
Standards (10%)	-----	6,500	124	6,500	\$124
Retrofit (30%)	2,269	55,680	1,076	95,680	\$1487.1
Residential					
I (20%)	903.25	29,516	578.75	46,516	\$713.75
II (30%)	1243.03	38,180	748.64	64,505	\$925.64
Industrial (16%)	\$1,392	-----	-----	-----	-----

Note: Indirect Impacts calculated using implicit increases in disposable income and fixed fiscal policies

Impacts for 1985 (Changes from Base Case)

50-1

Conservation Events (Energy Savings)	Total Energy Use		Sector Price % Change	Cost of Living % Change	Regional Product		Jobs	
	% Change	Savings 10 ¹² BTU			% Change	Value	%	No.
Commercial								
Standards (10%)	- 3.5%	133	- .45%	- .26%	+ .08%	-----	+ .06%	3,600
Retrofit (30%)	- 10%	399	- 1%	- .57%	+ .1%	\$ 600 mil	+ .2%	18,700
Residential								
I (20%)	- 7%	239	- 19%	- .65%	+ .45%	916	+ .4%	25,000
II (30%)	- 10%	382	- 29%	- 1%	+ .7%	1425	+ .56%	35,000
Industrial	- 3.95%	150	- .60%	- .22%	+ .01%	-----	-----	-----

NEW ENGLAND COMMERCIAL ENERGY USE

The impact analyses of higher energy costs in the commercial sector are most often based on vague notions of "achievable cost-effective percentage reductions in demand." This paper explicitly details the "macro" projections of changes in commercial energy use to a more disaggregated basis.

First, the inexact nature of energy-use statistics is discussed. This leads to a description of the predominant method of disaggregating commercial energy use. Here, annual energy consumption is linked directly to commercial floor-space and detailed by type-of-building and energy end-use. This is followed by an examination of the present New England commercial energy-use patterns; ~~in aggregated form~~, these commercial energy-use figures are checked against present base-year data and provide an excellent match.

At this point, general economic growth conditions and their anticipated effect on the New England commercial sector are set forth. Using these estimated growth patterns, future energy use can be forecast through 1985 under a variety of conservation assumptions. At first, energy conservation patterns are merely hypothesized with little description of how these energy savings might occur; but this is immediately followed by a discussion of particular energy-saving projects that can be initiated.

The data that are presented in this report provide descriptive detail, and much has been culled from previous studies of either New England or commercial energy demands. It is anticipated that this macro-and-micro assembly will be used later as a benchmark for measuring policy alternatives.

Energy-Use Statistics and the Commercial Sector

Energy-use data for each state has been collected from the energy suppliers and compiled into a data base called "Strawman". As in all data collection, care has been taken to separate items into categories in order to make useful distinctions. As often happens, this process of division and categorization, in an effort to maintain consistency across categories, requires some rather inexact allocations between sectors. In "Strawman", data on the use of electricity has been taken from reports of the Edison Institute. While efforts have been made to separate commercial from residential from industrial uses, the electric utilities cannot adequately separate "master metered" apartments and other "pseudo-commercial" ventures from the usual commercial sector. Analogously, energy-use statistics for natural gas, oil, and coal have been obtained from the Bureau of Mines; and the disaggregation of energy-use to the commercial, residential, and industrial sectors has required general approximations which have over-estimated commercial energy use.

Thus, if we had defined the commercial sector (as ADL and Brookhaven did) to include only offices, retail, schools, hospitals, and miscellaneous commercial buildings (such as hotels, motels, dormitories, amusement and recreational buildings, religious buildings, etc.) then the "Strawman" data would overstate the energy use of this "narrowly defined" commercial sector.

ADL and Brookhaven, in two of the reports cited in the Appendix, have (implicitly) estimated that this overstatement is most serious in the oil and natural gas statistics, and might represent 20 to 25 percent of the Strawman figures. Overstatement of commercial use would be only a slight problem in the electricity figures, and a nonexistent one in coal use.

ADL and Brookhaven have studied energy use in their narrowly-defined commercial sector and have used an identical methodology to describe its components. Basically, this methodology consists of identifying the amount of commercial floorspace of each of the commercial building types, simulating energy use as determined by floorspace area and type of building, estimating different efficiencies for different fuels, and estimating the fraction of buildings using each fuel type. These steps are combined to give a more detailed picture of what fuel is being used for what purpose and by whom.

This report follows that pattern for the narrowly defined commercial sector, but then goes a necessary step further and adds a building category called "other" which is meant to capture the energy use of apartments and other pseudo-commercial energy uses.

We have included this "other" category in order to parallel the Strawman data. This data base was used in the development of the New England Macroeconomic Energy Model, and consistency requires that it be used here. More importantly, it is felt that these "other" commercial buildings probably do respond to energy costs in a fashion more akin to the commercial sector than the residential sector. Also, conservation techniques in these "other" buildings probably resemble those used by the commercial sector.

Commercial Capital Stock Estimates, Energy Intensity, and Fuel Mix

Using historical data, the effects of real income, population, and number of households on the level of commercial activity and new commercial construction have been empirically estimated. Construction of commercial buildings (by type) was analyzed for the U.S. as a whole, and then regionalized by the shares of key economic activity and population. The two major studies of New England floorspace arrived at almost identical conclusions. The Brookhaven estimates are shown in Table A of the Appendix. For our purposes, New England figures (updated to 1974) and their appropriate stock replacement rates are given in Table I on page 4.

The stock replacement rates for the different building types were estimated in the empirical study of commercial construction; but to project commercial activity and energy use in the future, general economic forecasts were needed. The Brookhaven Report forecasts a steady 1.3% per annum growth in New England population - from 12.105 million in 1972 to 15.226 million in the year 2000. As a result of declining birth rates and fewer persons per household, the number of households will grow at a 2% annual rate from 3.72 million in 1972 to 5.44 million in the year 2000. The Arthur D. Little Report uses the more conservative estimates of 0.8% per annum for population increase in the Northeast, and a 4.4% annual growth in real personal income. Using either set of general economic projections, the results are nearly the same.

Table I illustrates the expected continuing growth of the New England commercial sector. Office and retail space will grow at a faster rate than either personal income or GNP. Schools, hospitals, and miscellaneous commercial activity* will grow faster than population, but will not keep pace with GNP. Overall, Table I hints at the important energy conservation role that will be played by the commercial sector as it assumes increasing importance in the New England economy. Commercial floorspace which has not yet been constructed will comprise a large portion of the total floorspace by 1985.

Energy use in the commercial sector is typically measured by annual energy use per square foot of floorspace for each of a variety of purposes and possible fuels. These measures are often called "unit demands" - they vary appreciably among different building types, and it is this figure which can be altered through conservation programs.

Table II on page 4 is the unit demand table used in this report. It is a description of energy technology and commercial energy use, as commonly practiced in New England. If the table is read across the row, it provides a comparison of how many BTU's of each particular fuel would be needed to provide the standard amount of useful output, if that fuel were to be utilized for that purpose. If the table is read down a column, it provides a comparison of the varying standard energy needs for the different types of commercial buildings.

* The "other" category will be discussed in a later section.

Table I. New England Building Stock (in 10^6 ft²) and Replacement Rates
(Annual Rates, Continuously Compounded)

	1974 stock	1974-85 Annual Rates			1985-2000 Annual Rates		
		Addition	Removal	Net Addition	Addition	Removal	Net Addition
Offices	259	5.54%	0.43%	5.11%	5.20%	0.21%	4.99%
Retail	307	6.16	0.39	5.77	5.64	0.17	5.47
Schools	305	3.73	0.55	3.18	1.91	0.43	1.48
Resp.	125	3.37	0.57	2.80	3.01	0.39	2.62
Resc. comm.	492	3.37	0.57	2.80	3.72	0.34	3.38
Other	259	3.37	0.57	2.80	1.91	0.43	1.48

Table II. Unit Energy Demand in the Commercial Sector

(in 10^3 BTU/ft² yr. at point-of-entry)

	Space Heating				Air Cond.		Hot Water			Equipment
	Gas	Oil	Elec.	Coal	Elec.	Gas	Elec.	Gas	Oil	Elec.
Offices	310	313	165	345	12.2	20.3	17	24.3	34	31.6
Retail	172	174	92	191	10.8	17.9	17	24.3	34	34.0
Schools	275	278	306	306	8.5	14.1	17	24.3	34	27.2
Resp.	333	336	176	370	12.0	20.0	17	24.3	34	71.3
Resc. comm.	172	174	92	191	10.8	17.9	17	24.3	34	31.6
Other	333	336	176	370	12.0	20.0	17	24.3	34	71.3

The first five rows of this table* are taken from Brookhaven's report on energy use and are specific to New England, with the exception that the oil column for water heating was developed by using the implied relative efficiencies of the ADL report**. This table actually evolved from computer simulations of energy use in prototypical buildings. It represents a "stylized" approximation, since no encompassing body of data on actual use exists at the present time. Brookhaven asserts that these estimates compare well with what little actual fuel use data is available, but the many methods of measuring floorspace complicate matters considerably.

Before we can use this Table II in conjunction with Table I to calculate fuel use patterns, we need to know what fraction of buildings use each fuel type for a particular purpose. For example, we need an estimate of the fraction of office space using oil for heating, just as we need an estimate of the fraction of hospitals using electricity for water heating. A table containing such information is called a fuel-mix or saturation table. The one used in this report is Table III on page 6.

The saturation rates that were used by Brookhaven are given in the Appendix. The table forwarded in this report (Table III) incorporates a slightly more realistic fuel mix for hot water heating, and a coal-use fraction designed to balance the base year. Otherwise, the two are nearly identical.

When the fuel-mix data of Table III is combined with the energy intensities of Table II and the 1974 floorspace estimates of Table I, it yields a theoretical disaggregated fuel-use pattern for the commercial sector of New England for 1974 - this fuel use pattern is shown in Table IV on page 6. Table IV represents a "stylized" version of commercial energy use, one which has been built up from estimates of floorspace, energy use per unit of floorspace, and fuel-mix percentages. It is "theoretical" in the sense that floorspace estimates have been "regionalized" from U.S. estimates on the basis of the New England shares of key economic activities, energy-use data have come from a simulation study, and fuel mixes (or saturation rates) roughly reflect previous estimates for New England.

* The "other" category will be discussed shortly.

** The Brookhaven and ADL "unit demands" are given in Tables B and C of the Appendix.

Table III.

Saturation Rates for New England
(fraction of buildings of each type which use the mode of operation)

	Space Heating				Air Cond.		Hot Water			Equip.
	Gas	Oil	Elec.	Coal	Elec.	Gas	Elec.	Gas	Oil	Elec.
offices	.105	.8841	.01	.0009	.964	.036	.2	.4	.4	1
retail	.105	.8841	.01	.0009	.964	.036	.2	.4	.4	1
schools	.105	.8841	.01	.0009	.196	.004	.2	.4	.4	1
hosp.	.105	.8841	.01	.0009	.964	.036	.2	.4	.4	1
misc. comm.	.105	.8841	.01	.0009	.196	.004	.2	.4	.4	1
other	.105	.8841	.01	0	.4	0	.2	.4	.4	0.1

Table IV. 1974 Theoretical Commercial Fuel Use in New England (in 10^{12} BTU)

	Space Heating				Air Cond.		Hot Water			Equip.
	Gas	Oil	Elec.	Coal	Elec.	Gas	Elec.	Gas	Oil	Elec.
offices	8.43	71.67	0.43	0.08	2.40	0.15	0.88	2.52	3.52	8.18
retail	5.54	47.23	0.28	0.05	3.20	0.20	1.04	2.98	4.17	10.44
school	8.80	74.96	0.44	0.08	0.51	0.02	1.04	2.96	4.15	8.30
hosp.	4.37	37.13	0.22	0.04	1.45	0.09	0.42	1.21	1.70	8.91
misc. comm.	8.88	75.69	0.45	0.08	1.04	0.03	1.67	4.78	6.69	15.55
other	9.06	76.94	0.46	0	1.24	0	0.88	2.52	3.52	1.85
	45.09	383.62	2.28	0.34	9.83	0.49	5.94	16.98	23.76	53.22

Balancing the Base Year - the "Other" Category

The totals of the disaggregated fuel use pattern of Table IV match the aggregate actual use figures as taken from the Strawman data base. (This match is illustrated in Table V on the following page.) However, by now it should be clear that the row entitled "other" really represents the discrepancies between the Strawman definition of commercial energy and that of both ADL and Brookhaven - only the first five rows.

While the sets of values found in this extra category might appear completely arbitrary, their determination process followed an outlining of "a priori" beliefs. First, since the problem was to account for the energy used primarily in multi-unit dwellings, and since residences represent an intensive use of energy, for Table II we chose the highest set of energy use figures already cited - those of hospitals. Second, we thought that the amount of 1974 floorspace in this category might roughly correspond to that of offices, so in Table I we repeated the office floorspace figure. Third, while expenditures for heating, cooling, and hot water might not have been handled by the individual tenant (and thus should be included in this category), private electrical use is usually paid on an individual basis, and thus should not be included in this category. This led to the choice of a small figure (0.1) in the equipment portion of Table III. Fourth, it seemed unlikely that any coal was being used for space heating in these buildings, so the coal fraction in Table III was set at zero. These figures provided an adequate accounting of the discrepancy in energy use; only one more set of values were needed before projections could be calculated.

So far, so mention has been made of the process that determined the addition and removal rates for floorspace in this category. Since, as mentioned previously, the number of dwellings is expected to increase 2% per annum, and since the addition rates of Table I tend to exceed this figure, the smallest set of rates was chosen. Through 1985, this projects a 2.8% per annum increase in floorspace. One might wish to interpret this not as a slight relative shift away from owner-occupied homes, but as the construction of slightly larger multi-unit dwellings.

Table V. Theoretical and Actual Fuel Use for 1974 (in 10^{12} BTU)

	<u>Coal</u>	<u>Nat. Gas</u>	<u>Elec.</u>	<u>Oil</u>
for 1974 (strawman)	.331	63.43	69.94	417.75
for 1974 (estimate)	.343	62.56	71.28	407.38

Table VI. ADL, Conservation in the Commercial Sector
(Percentage Reduction in Unit Demands)

	<u>Space Heating</u>	<u>Cooling</u>	<u>Hot Water</u>	<u>Equipment</u>
(in existing)				
offices	22	18	5	12
retail	24	24	5	17
schools	21	19	5	12
hosp.	16	9	0	12
misc. comm.	24	24	5	12
other	16	9	5	12
(in new)				
offices	40	47	10	30
retail	50	46	10	30
schools	50	41	10	30
hosp.	40	33	10	25
misc. comm.	50	46	10	30
other	40	33	10	25
(combined effect by 1985)				
All	32	31	7	22

Energy Programs and Scenarios

Six commercial fuel use scenarios for 1985 are presented in Table VII on page 10. In each, the stock of commercial floorspace was updated as suggested in Table I, and the fuel use for new (1975-85) and old (pre-1975 buildings still existing in 1985) buildings were calculated separately.

The first fuel use pattern for 1985 is entitled "no change". The base year fuel mix patterns and unit energy demands are applied to all buildings. However, one change has been made; the saturation rate of air-conditioning has been increased from 0.2 to 0.4 for all schools and miscellaneous buildings. This follows the standard procedure used by both Brookhaven and ADL, and assumes an increasing popularity of air conditioning in these buildings.

In their report, Brookhaven investigates three scenarios; all are re-estimated here using the larger definition of the commercial sector, which implies consistency with the New England Macroeconomic Energy Model. Preceding each scenario, Brookhaven provides an introductory discussion of the economic forces which could motivate the energy-saving behavior that they describe.

Their initial scenario is called the "base" case. Here, only the rudimentary, imperfect market forces motivate a change in energy patterns. These market forces result in reduced demand in existing buildings (i.e., lowered thermostats, improved operating procedures, and reduced lighting levels). Specifically, by 1985, all presently existing and newly constructed buildings will achieve a 15% unit energy reduction in heating demand and a 10% unit energy reduction in cooling demand. Again, fuel mixes remain the same while air conditioning saturation in schools and miscellaneous is changed from 0.2 to 0.4 for all such buildings.

Brookhaven's second scenario is a moderate conservation case. Here, the government operates to improve energy awareness and remove market imperfections. All conservation measures that are taken are clearly in the economic self-interest of the consumer. Existing structures realize a 20% reduction in unit demands by 1985. New structures realize a 35% reduction in unit demands by 1985. Fuel mixes remain the same, but again, air conditioning saturation in schools and miscellaneous is increased. After 1985, solar energy space heating systems are installed in 20% of the new structures and provide 50% of the energy needs for space heating in these buildings; solar energy also provides 35% of the energy used in hot water heating in new buildings of the 1985-2000 vintage.

The last Brookhaven scenario is a strong conservation case. Direct government regulations and the alteration of market prices create some economic sacrifices. Existing structures realize a 25% demand reduction by 1985 and a 35% reduction by 2000. New structures realize a 50% demand reduction by 1985. Solar energy could provide 50% of the space heating energy and 70% of the hot water demand for buildings built after 1985. Again, fuel mixes remain the same while air conditioning saturation in all schools and miscellaneous is increased.

The ADL commercial energy projection for 1985 is based on a notion of cost-effective energy reductions in demand. More attention was paid to detailing conservation figures and conservation costs. Of course, this still results in only a rough calculation of profitable conservation by building types. The ADL

Table VII. New England Commercial Energy Use Scenarios (in 10¹² BTU'S)

	Space Heating					A/C				Hot Water				Equipment
	Gas	Oil	Elec.	Coal	Solar	Elec.	Gas	Elec.	Gas	Oil	Solar	Elec.		
1974	45.09	383.62	2.28	0.34	0	9.83	0.49	5.94	16.98	23.76	0	53.22		
1985	(only more air conditioning)													
"Base" case	Old	41.17	350.28	2.08	0.32	0	10.46	0.45	5.42	15.51	21.70	0	48.62	
	New	26.93	229.10	1.36	0.22	0	7.80	0.38	3.61	10.33	14.45	0	33.00	
		68.10	579.38	3,44	0,54	0	18,26	0,83	9,03	25.84	36.15	0	81.62	
Mild conservation	Old	35.00	297.74	1.77	0.27	0	9.41	0.40	5.42	15.51	21.70	0	48.62	
	New	22.89	194.74	1.16	0.18	0	7.02	0.34	3.61	10.33	14.45	0	33.00	
		57.89	492.48	2.93	0.45	0	16.43	0.74	9.03	25.84	36.15	0	81.62	
Strong conservation	Old	32.94	280.22	1.67	0.25	0	8.37	0.36	4.34	12.41	17.36	0	38.89	
	New	17.50	148.92	0.89	0.14	0	5.07	0.25	2.35	6.71	9.39	0	21.45	
		50.44	429.14	2.56	0.39	0	13.44	0.61	6.69	19.12	26.75	0	60.34	
ADL	Old	30.88	262.71	1.56	0.23	0	7.85	0.34	4.07	11.63	16.27	0	36.46	
	New	13.46	114.55	0.68	0.11	0	3.90	0.19	1.81	5.16	7.23	0	16.50	
		44.34	377.26	2.24	0.34	0	11.75	0.53	5.88	16.89	23.50	0	52.96	
	(Reductions given in Table VI)													
	Old	32.67	277.90	1.65	0.24	0	8.50	0.36	5.17	14.79	20.69	0	42.30	
	New	14.77	125.69	0.75	0.12	0	4.37	0.21	3.25	9.30	13.01	0	23.34	
		47.44	403.59	2.40	0.36	0	12.87	0.57	8.42	24.09	33.70	0	65.64	

Table VII. New England Commercial Energy Use Scenarios (in 10¹² BTU's)

		Space Heating				A/C	Hot Water			Equipment			
		Gas	Oil	Elec.	Coal	Solar	Elec.	Gas	Oil	Solar	Elec.		
1974		45.09	383.62	2.28	0.34	0	9.83	0.49	5.94	16.98	23.76	0	53.22
1985	No change	(only more air conditioning)											
(repeated)	Old	41.17	350.28	2.08	0.32	0	10.46	0.45	5.42	15.51	21.70	0	48.62
	New	26.93	229.10	1.36	0.22	0	7.80	0.38	3.61	10.33	14.45	0	33.00
		68.10	579.38	3.44	0.54	0	18.26	0.83	9.03	25.84	36.15	0	81.62
Building Standards (Old use 15% less for all purposes, ADL Table VI Reductions for new post-1977)													
Stand - I	Old	40.41	343.82	2.05	0.31	0	11.03	0.49	5.33	15.25	21.34	0	47.91
	New	11.28	95.94	0.57	0.09	0	3.58	0.18	2.49	7.11	9.94	0	17.86
	26%	51.69	439.76	2.62	0.40	0	14.61	0.67	7.82	22.36	31.28	0	65.77
(Old use 20% less for all purposes, ADL Table VI Reductions for new post-1977)													
Stand - II	Old	38.04	323.59	1.93	0.29	0	10.38	0.46	5.02	14.35	20.08	0	45.09
	New	11.28	95.94	0.57	0.09	0	3.58	0.18	2.49	7.11	9.94	0	17.86
	28%	49.32	419.53	2.50	0.38	0	13.96	0.64	7.51	21.46	30.02	0	62.95

percentage reductions in demand are shown in Table VI on page 8 along with the conservation figures chosen for the "other" category. These were used in re-estimating the projections to be consistent with Strawman data and the New England Macroeconomic Model. Again, fuel mixes remained the same while air conditioning saturation in all schools and miscellaneous is increased.

The above "ADL" scenario applies the ASHRAE 90-75 reductions to new buildings as of 1975. Since new building construction has been somewhat depressed over the last few years, applying those building standards to linear trend building additions beginning in 1975 may actually conform with immediate (1978) application of these standards for new buildings. That is, it could be assumed that a large percentage of the additions projected for the 1975-1978 period would actually be constructed in the 1978-1985 period. Due to this uncertainty, two projections are made applying building standards to new post 1978 buildings. The first assumes a 15% reduction for all uses, the second 20% reductions.

The figures in Table VII indicate potential energy savings over 1978 use patterns of up to 35% for the strong conservation case. The mild conservation case would reduce use 26%, the "ADL" case 27%. The cases reflecting adoption of building standards in 1978 would save 23% for "Stand I" and 26% for "Stand II". Since the Energy Policy and Conservation Act mandates adoption of a building standard similar to ASHRAE 90-75 by January, 1978, reductions in energy use (relative to 1974 use patterns) of at least 23% should be expected. Total use reductions approaching 30% must be considered highly feasible, particularly considering the potentially high saturation rates of air conditions given by the Brookhaven study.

Energy Conservation

Studying commercial fuel use, it quickly becomes apparent that the lack of actual operational data for existing buildings makes computer simulation seem an attractive method for estimating the savings that accrue from specific energy conservation projects and for pinpointing the key determinants of excessive energy use. But, given that actual fuel use for similar purpose buildings may vary by as much as 400%, computer simulations cannot be a perfect substitute for field data.

The first major lesson to be learned from simulations is that the energy-effect of building shell design is not at all obvious. Only in predominantly cold climates, like the Northeast, is it clear that less thermal conductivity of commercial building shells will lead to less energy use.

In a report entitled, "Energy Conservation in Non-Residential Buildings", the Rand Corporation details the "load" factors that influence energy use. Four thermal loads are examined: (1) shell transmission, (2) solar radiation, (3) ventilation and infiltration, and (4) internal loads. The dominant commercial energy use in New England is space heating; shell transmission and ventilation are the key concerns in this regard.

Table VIII. Relative Influence of Load Components on Energy Use
(Percent of Total Effect: Parentheses Indicate Reducing Effect)

<u>Component</u>	<u>Heating</u>	<u>Cooling</u>
Internal Cond.	(24)	42
Solar Gain	(5)	11
Cold Weather	57	(17)
Hot Weather/Humidity	0	10
Unexplained	14	20

Lighting

Lighting is the single most influential internally controlled energy load in the commercial sector and plays a pivotal role in energy system use. Throughout the recent past, the IES lighting-level standards have more than kept pace with the increasing technical orientation of office work and have increased to the point where some standards require 150 footcandles. Arthur D. Little studies estimate that moving from an IES standard to GSA's 50-30-10 rule* could mean a 50% lighting energy reduction for a general office building. This would reduce the cooling load drastically while increasing heating system requirements. Rand simulations show that doubling the lighting level in a glass office building in New York City (which has a full lighting load for 44% of the time but does not utilize nighttime temperature setbacks) will reduce the heating requirement by 25% (mostly nighttime needs) but will increase the cooling requirement by 75%.

Applications of the ASHRAE 90-75 standards to non-residential buildings implies a reduction in lamps and lamp fixtures averaging 24% and 22%, respectively. This calculation includes the partially offsetting increased demand for artificial lighting as window areas are slightly reduced.

Operating Procedures

The overwhelming conclusion of conservation studies is that most of the energy savings in the commercial sector can be realized through improved monitoring equipment and operating procedures.

While dual set-point thermostats are commonplace in the residential sector, many commercial buildings operate without use of a "dead-band". The quality of the controls that are used is also typically poor; temperature resolution on the order of ± 2 to 5°F is widespread, and this contributes to useless system operation. In Rand simulations, if a 6° "dead-band" below 72°F was used instead of a fixed-set 72°F,

* Refers to lighting levels: 50 footcandles for work areas, 30 footcandles for ambient lighting, 10 footcandles for corridors.

so that heating occurs up to 66°F and cooling down to 72°F, then the heating requirement for the exterior zones in a glass office building in New York was reduced by 32% and the cooling requirement was reduced by 4%. Other methods that can be adopted include sensible and enthalpy heat exchangers, and heat pumps. In more moderate climates, with an even mix of heating and cooling demands, heat pumps have been shown to reduce energy demand up to 60%. Of course, nighttime setback in buildings limited to only daytime use has been documented as saving up to 20%.

Economizer cycles are a particularly attractive alternative to present energy use patterns, and provide a clear example of better monitoring equipment and control systems yielding substantial savings.

In a recent publication of the Federal Energy Administration entitled "Identifying Retrofit Projects for Buildings",

"When the outside air conditions (temperature and humidity) are similar to the conditions required for delivery from the air handling unit, it is desirable to have this air introduced into the building. If the outside air conditions do not closely match the inside requirements, it is desirable to introduce the smallest amounts required by law. An economizer cycle will allow the outside air and inside air to mix in the proper proportions so that the least amount of energy must be expended to get the air to the required conditions. The economizer cycle is provided by automatic dampers in the air ducts, controlled by sensors that monitor air temperature and humidity. This option is used for central air distribution systems and not for individual fancoil units located in the outside walls of some buildings. The economizer cycle can reduce the energy used for heating and cooling by 20%."

Of course, the energy savings that might accrue from use of these cycles is greatly diminished or increased when outside air ventilation rate regulations are altered.

In terms of sectorwide conservation potential and procedural savings, Rand concluded, "Energy use intensity in the commercial sector can be reduced by 46 to 50% over pre-embargo practice". Further, "most of the savings can be achieved by changes in operating procedures rather than by modified building or equipment designs".

Building Shell Characteristics

The Northeast is one section of the country where erecting buildings with reduced thermal transmission characteristics is clearly in the economic self-interest of the owner-operator. Better thermal design has two distinct savings potentials. First, it reduces the normal energy consumption of the heating system, thus lowering average operating costs. Second, it dramatically reduces the necessary cooling capacity.

The ASHRAE standard 90-75 is a concerted effort towards energy conservation in buildings, both residential and commercial. Sections 4 thru 9 of that standard provide a component approach to energy use and contain a few prescriptive requirements. The standard appears to be most effective in reducing annual heating requirements in the non-residential buildings of the Northeast. In simulations of prototypical building use, ADL found that the lowest obtainable energy use that might result from performing even the measures that were only "recommended" was 67,000 to 72,000 BTU's per square foot, considerably higher than the GSA's announced "goal" of 55,000 BTU's per square foot. The ASHRAE 90-75 standards, while broad in scope, primarily impact energy use by requiring less thermal conductivity of the building shell.

Application of the standard to commercial buildings has dramatic effects. While external window area is reduced slightly, it must now be double-glazed, resulting in somewhat higher glass costs for construction. Wall and roof areas require improved insulation and reduced transmission factors; lighting and outside ventilation are reduced. Higher design costs would also be confronted. Yet, overall, initial unit costs of construction remain unchanged or even fall slightly.

To get a better idea of the change in construction costs that would occur in New England, Table IX shows that Massachusetts usually experiences 6,000 annual heating degree days (a measure of winter weather severity) and thus falls somewhere between the conditions of Region A and Region B. Northern regions of New England are best approximated by Region B, while southern regions resemble Region A.

Table IX

Design Characteristics

	<u>Simulations</u>		<u>Massachusetts</u>	
	<u>Region A</u>	<u>Region B</u>	<u>Common Practice</u>	<u>New Standards</u>
Annual Heating Degree Days:	5,219	6,612	6,000	6,000
Summer Design: dry-bulb	87 ⁰	94 ⁰	92 ⁰	88 ⁰
wet-bulb	76 ⁰	78 ⁰	75 ⁰	74 ⁰

Changes in Construction Costs (Dollars per Sq. Ft. of Floorspace)

	<u>Region A</u>	<u>Region B</u>
Single-family residence	+ 0.01	- 0.04
Multi-family low-rise	- 0.45	- 0.54
Office building	- 0.35	- 0.29
Retail store	- 0.11	+ 0.04
School	- 0.56	- 0.39

While savings in lighting fixtures and power distribution systems partially offset the higher costs of better insulated walls, ceilings, and floors, the cost reductions in initial construction stem primarily from savings in heating and cooling equipment through reductions in necessary design capacities. A small office building of 40,000 square feet, which might presently require 107 tons of heating capacity and 162 tons of cooling capacity, under ASHRAE 90-75 construction standards would require only 69 tons of heating capacity and 93 tons of cooling capacity. As these figures suggest, many total comfort systems presently contain excess heating capacity and are constrained by summer cooling needs. Table X on page 16 gives a more detailed description of altered costs of construction.

In terms of designing and building new structures, it appears that more "energy-conservative" buildings can even be less expensive to construct than conventional buildings. This saving would be added to the dramatic reduction in energy needs that are estimated in Table XI. With such great potential for cost reductions in new buildings, it would seem that this standard would have been adopted as a suggested reference much sooner. Of course, stricter design patterns would tend to "front-load" the intricacies of the building process.

However, while ASHRAE modifications result in considerable energy savings, it is questionable whether the energy savings alone could justify such extensive building modifications in existing structures: retrofit costs are bound to be considerably higher than those incurred by incorporating energy-saving materials into the original construction. Yet, profit margins can be affected considerably through the higher operating costs imposed by rising energy prices. Rand estimates that a doubling of fossil fuel prices could cut into cash flow appreciably, and reduce a 10% return on investment to a 9% return.

Generally, if the cost implications of building design were more widely recognized, perhaps more attention would be paid to producing more efficient structures. Presently, design architects choose building materials and determine structural characteristics, and with only a limited understanding of their potential contribution to dramatic energy-use reductions.

Conservation Experience

Recently, with the rise in fuel prices, private enterprise has begun to spawn energy-conservation engineering firms, many of which have amassed some New England experience. Sizable energy savings appear to be possible through a number of modifications or operational changes. Vanderweil Engineers, a Boston-based firm, has graciously provided some insight into the wide scope of services that they have fielded in New England.

These conservation figures are presented in Table XII on page 18 and reflect the fact that "exotic" energy systems are not usually affixed to existing structures. Exotic energy systems must be fully integrated with building design if they are to prove their economic superiority.

Total Energy Systems and Solar Augmentation

The Rand report compares the costs of seven different types of energy systems; each either partially or wholly supplies the energy needs for a New York glass-curtainwall (100% glass exterior) office building of 360,000 gross square feet. The cost comparisons are reprinted in Table XIII on page 19. Exact equipment

TABLE X
Estimated Unit Costs of Conventional vs ASHRAE 90-75 Modified Buildings
(Dollars per sq. ft. of Floor Area)

	Single Family		Multi-Family		Office Building		Retail Store		School	
	Conv.	90-75	Conv.	90-75	Conv.	90-75	Conv.	90-75	Conv.	90-75
Exterior walls Region A Region B	1.70 1.65	1.70 1.66	0.92 0.90	0.96 0.96	2.69 2.62	3.14 2.95	0.85 0.83	0.99 1.04	1.62 1.58	1.65 1.66
Glass Region A Region B	1.23 1.20	1.23 1.15	1.15 1.12	1.02 0.88	1.03 1.00	1.07 1.24	0.40 0.39	0.40 0.34	0.56 0.55	0.52 0.44
Roof Region A Region B	1.11 1.08	1.18 1.15	0.56 0.55	0.60 0.58	0.73 0.71	0.88 0.86	2.18 2.12	2.62 2.77	2.18 2.12	2.62 2.77
Floor Insulation Region A Region B	- -	0.03 0.03	- -	0.02 0.02	- -	- -	- -	0.02 0.02	- -	- -
HVAC equipment Region A Region B	0.83 0.84	0.78 0.79	1.88 1.89	1.65 1.67	3.88 3.91	3.50 3.52	2.65 2.67	2.34 2.36	2.87 2.89	2.47 2.50
HVAC distribution Region A Region B	1.01 1.05	0.94 0.97	2.31 2.40	2.04 2.12	4.73 4.90	4.26 4.42	3.24 3.36	2.86 2.97	3.50 3.63	3.02 3.13
HVAC controls Region A Region B	0.36 0.36	0.36 0.36	0.06 0.06	0.06 0.06	0.39 0.40	0.50 0.52	0.11 0.11	0.11 0.11	1.13 1.14	1.13 1.14
Lighting Region A Region B	0.42 0.43	0.42 0.43	0.35 0.36	0.35 0.36	2.20 2.27	2.17 2.23	0.98 1.01	0.95 0.98	1.53 1.58	1.46 1.50
Elect. Distribution Region A Region B	0.49 0.49	0.49 0.49	0.41 0.41	0.41 0.41	6.20 6.14	5.92 5.86	1.05 1.04	0.95 0.94	1.91 1.89	1.80 1.78
Water Heating Equipmt. Region A Region B	0.08 0.08	0.08 0.08	0.10 0.10	0.14 0.14	0.09 0.09	0.11 0.11	0.11 0.11	0.12 0.12	0.23 0.23	0.25 0.25
Water Distribution Region A Region B	0.95 0.98	0.98 1.01	1.16 1.19	1.20 1.24	1.68 1.73	1.72 1.77	1.12 1.15	1.15 1.18	1.50 1.55	1.55 1.60

Table XI

Percentage Reductions in Annual Energy Consumption for ASHRAE 90-75 Modified Structures (Basis is Conventional Use)

	<u>Heating</u>	<u>Cooling (Chiller)</u>	<u>Auxiliaries</u>	<u>Humidification</u>	<u>Fans</u>	<u>Water Heating</u>	<u>Lighting & Power</u>	<u>Overall Avg.</u>
Single-family homes								
Region A	14.6%	33.3	-	-	-	29.9	0	14.7
Region B	13.9%	37.9	-	-	-	29.8	0	15.0
Low-rise apartments								
Region A	57.4	50.0	36.4	-	71.9	30.1	20.5	51.0
Region B	30.0	58.8	40.5	-	71.9	30.1	20.5	32.2
Office buildings								
Region A	76.0	38.2	37.2	93.4	60.2	29.6	29.1	61.5
Region B	73.5	35.2	54.0	92.0	61.1	29.6	29.1	61.2
Retail stores								
Region A	80.1	7.7	33.3	-	42.6	30.1	31.5	41.6
Region B	63.9	17.3	41.8	-	50.9	30.1	31.5	42.5
School buildings								
Region A	58.8	44.8	55.3	-	33.3	29.6	20.0	45.5
Region B	44.9	50.0	58.7	-	33.3	29.6	20.0	43.8

Source: Kling-Lindquist, Inc., based on computer simulations.

TABLE XII

Energy Projects in New England						
<u>Locale</u>	<u>Type</u>	<u>Gross Sq Ft</u>	<u>Investment</u>	<u>Yearly Saving</u>	<u>Modification</u>	<u>Raw source energy (MBTU/sq.ft. - yr)</u>
N.H.	college building	50,000	\$ 14,000	\$ 15,600	HVA/C controls, reduction of outside air	
Ma.	industrial complex	1,200,000	\$ 40,000	\$ 30,000	Improved HVAC/C controls	
Me.	post office	245,000	\$ 59,000	\$ 74,400	HVA/C controls, lighting	302 to 163
Ma.	fire station	2,100	\$ 1,500	\$ 500	Architectural changes	
Vt.	college building	392,000	\$ 40,500	\$ 22,800	HVA/C modified	518 to 400
R.I.	office bldg. (met GSA requirements beforehand)	235,000	\$ 15,000	\$ 4,500	Operational changes, and stock economizer	185 to 180
Ma.	Hotel	382,000	\$220,000	\$105,000	Insulated boilers and replaced purchased steam	
Conn.	College	1,400,000	\$110,000	\$ 32,000	Partial summer shutdown	291 to 280
Vt.	College	300,000	\$ 36,000	\$ 31,000	Demand load limiting	

TABLE XIII

SUMMARY OF ENERGY INTENSITIES AND ESTIMATED COSTS OF REPRESENTATIVE BUILDING ENERGY SYSTEMS

Building Energy System	Primary Energy Consumption MBtu/sq ft/yr	Installed First Cost (\$ Million)	Annual Operating Cost (\$ Million)		Life-Cycle Costs: Discounted Present Value of After-Tax Cash Flow for Combinations of Electricity and Natural Gas Prices (\$ Million)			
			1973 Energy Prices ^a	Estimated Future Energy Prices ^b	Electricity and Natural Gas Prices (\$ Million)		Future Gas & Future Elect.	
					1973 Gas & Electricity 1973 Elect.	1973 Gas & Future Elect.		
Full-light Cases ^c								
Reference	313.3	1.400	.293	.424	1.24	1.53	1.27	1.56
Absorption	376.8	1.297	.288	.439	1.19	1.43	1.31	1.55
Economy	289.7	1.328	.272	.394	1.16	1.43	1.19	1.46
Reheat	357.4	1.878	.329	.478	1.51	1.81	1.57	1.87
Electric	361.1	1.218	.347	.502	1.30	1.68	1.30	1.68
Central Plant	306.7	1.599	.272	.398	1.26	1.50	1.33	1.57
Total Energy	297.5	1.855	.160	.263	1.08	1.08	1.33	1.33
Half-light Cases ^d								
Reference	192.8	1.018	.174	.253	.81	.96	.84	1.00
Absorption	232.2	.943	.171	.261	.77	.89	.86	.99
Economy	175.6	1.072	.163	.235	.78	.92	.82	.96
Reheat	237.5	1.366	.204	.300	1.01	1.18	1.08	1.24
Electric	252.8	.876	.244	.352	.92	1.19	.92	1.19
Central Plant	177.8	1.163	.158	.230	.82	.95	.87	1.00
Total Energy	191.1	1.272	.105	.172	.74	.74	.91	.91

^a 1973 energy prices: \$.97/million Btu for natural gas and \$7/million Btu for electricity (commercial rates).^b Estimated future energy prices: \$1.94/million Btu for natural gas and \$10.5/million Btu for electricity.^c Full light = 5.4 W/sq ft.^d Half light = 2.7 W/sq ft.

descriptions and performance characteristics are supplied in the Appendix.

As one would suspect, equipment that is favored for its low initial cost or its ability to provide maximum individual comfort control does not happen to be that which is least expensive in terms of the present discomfort value of its equipment and operating costs. Terminal re-heat systems can provide individualized and responsive climate control, but they are by far the most expensive. Total electric systems might appear cheap at the outset, but higher operating costs gradually outweigh the initial savings. Yet, while total energy systems appear to be lowest in life-cycle costs, they have a high initial cost and force the building owner to provide an uninterrupted supply of primary fuel.

In the cost calculations of Table XIII on page 19, energy sources were assumed to be either natural gas or purchased electricity, or both, depending on the particular building energy system. Life-cycle costs represent the present value of annual after-tax cash flow that would be experienced by a building owner who borrowed 80% of the installed first cost for 20 years and at 10%, paid total federal and state income taxes at a composite rate of 50% of taxable income, recovered 10% of the installed first cost as salvage value at the end of 10 years, and had a discount rate of 20%.

As far as incorporating more "exotic" energy sources into commercial buildings is concerned, Section 11 of ASHRAE standard 90-75 allows energy consumption standards to be met through partial use of non-depletable resources. ADL attempted to calculate the "optimum" size of solar energy systems for commercial building use. They estimated the average costs of different amounts of useful power that could be supplied, and selected the system with the minimum average cost. Present flat-plate collector technology was assumed and the results indicated that solar might provide 30% of the energy needed for hot water or 10% of the energy needed for space heating and hot water. Given the lack of experience in applications of solar technology to commercial buildings, these calculations can only be considered rough at best. This 10% estimate was used in the final 1985 scenario that is shown on page 10.

Concluding Remarks

Energy use in the commercial sector will experience almost relentless growth, not as a result of more profligate use of energy, but as a result of additions to presently existing commercial floorspace. This is an unavoidable part of economic growth. While construction patterns of the recent past leave a great deal of room for conservation measures which are clearly in the economic self-interest of building owners and occupants, new construction guidelines offer the greatest hope of reducing future energy consumption in New England. Dissemination of technical material on improved operating systems would also appear to be a high priority.

If a substantial conservation effort in the commercial sector is pursued, then, even though gas and oil consumption may be held at present levels, there will still be great increases in the amount of electrical power demanded by the commercial sector by 1985. Referring back to Table VII on page 10, it becomes apparent that electrical equipment demands will substantially increase under all but the strongest of conservation efforts.

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APPENDIX

Table A. Brookhaven's Commercial Floorspace Projections for New England (in 10^6 ft²).

	<u>1972</u>	<u>Additions 1972-85</u>	<u>Removals 1978 -85</u>	<u>1985</u>	<u>Additions 1985-2000</u>	<u>Removals 1985-2000</u>	<u>2000</u>
offices	234	247	26	455	538	31	962
retail	274	336	30	580	772	35	1317
schools	287	179	32	434	144	36	542
hospitals	118	65	13	170	97	15	252
misc.	465	256	52	669	501	59	1111

Table B. Brookhaven's New England Commercial Energy Unit Demands (in 10^3 BTU/ft² yr)

	<u>Space Heating</u>				<u>Air Cond.</u>		<u>Hot Water</u>			<u>Lighting & Appliances</u>
	<u>Gas</u>	<u>Oil</u>	<u>Elec.</u>	<u>Coal</u>	<u>Elec.</u>	<u>Gas</u>	<u>Elec.</u>	<u>Gas</u>	<u>Oil</u>	<u>Elec.</u>
offices	310	313	165	345	12.2	20.3	17	24.3	-	31.6
retail	172	174	92	191	10.8	17.9	17	24.3	-	34.0
schools	275	278	146	306	8.5	14.1	17	24.3	-	27.2
hospitals	333	336	176	370	12.0	20.0	17	24.3	-	71.3
misc.	172	174	92	191	10.8	17.9	17	24.3	-	31.6

(under the assumption of 6,320 annual heating degree days)

Table C. New England Fuel-Use Fractions (saturation rates) as Simulated by Brookhaven

	<u>Space Heating</u>				<u>Air Cond.</u>		<u>Hot Water</u>			<u>Lighting & Appliances</u>
	<u>Gas</u>	<u>Oil</u>	<u>Elec.</u>	<u>Coal</u>	<u>Elec.</u>	<u>Gas</u>	<u>Elec.</u>	<u>Gas</u>	<u>Oil</u>	<u>Elec.</u>
offices	0.084	0.916	0	0	0.964	0.036	0.2	0.8	0	1.0
retail	0.084	0.916	0	0	0.964	0.036	0.2	0.8	0	1.0
schools	0.084	0.916	0	0	0.196	0.004	0.2	0.8	0	1.0
hospitals	0.084	0.916	0	0	0.964	0.036	0.2	0.8	0	1.0
misc.	0.084	0.916	0	0	0.196	0.004	0.2	0.8	0	1.0

Table D. ADL's Northeast Commercial Demands* (in 10^3 BTU/ft² yr)

	Space Heating				Air Cond.		Hot Water			Lighting & Appliances
	Gas	Oil	Elec.	Coal	Elec.	Gas	Elec.	Gas	Oil	Elec.
offices	96	113	44	-	10.9	-	3.4	4.8	6.8	39.1
retail	52	63	22	-	12.2	-	1.7	2.4	3.4	46.2
schools	85	100	40	-	9.2	-	3.4	4.8	6.8	38.4
hospitals	103	122	46	-	13.6	-	17.0	24.0	34.0	130.9
misc.	52	63	22	-	12.2	-	1.7	2.4	3.4	46.2

(under the assumption of 5,470 annual heating degree days)

* This table implicitly includes the effects or saturation rates on fuel mixes. That is, it is the result of a multiplication of two tables similar to Tables B and C of this Appendix. However, since this table represents the entire Northeast, it relies on winter conditions and fuel mixes that are not consistent with New England patterns.

Descriptions of Energy Systems

The Reference system consists of electric air conditioning, gas-fired hydronic (hot-water) heating, and a single-duct variable-volume air-distribution system.

The Absorption system is the reference system with absorption rather than electric air conditioning.

The Reheat system is the reference system with a double-duct constant-volume air distribution system. Warm air is circulated through one duct, chilled air is circulated through the other, and the two are blended at the outlet to achieve the desired temperature. This system provides excellent temperature control but at the expense of additional capacity and energy requirements.

The Electric system is the reference system with electric heating.

The Economy system is the reference system with selected thermal load-reducing devices.

A ventilation economizer cycle is used to take advantage of favorable outside temperature conditions. A heat wheel is added in the ventilation exhaust and intake stream to transfer a portion of the thermal energy in the already conditioned air from the output to the input. This system also includes a mechanism for exhausting a portion of heat generated by lighting to reduce cooling requirements.

The Central plant system differs from the reference system in that it uses prime mover driven centrifugal chillers along with piggy-back absorption chillers utilizing the heat rejected from the prime movers.

The Total Energy system uses prime mover engines to generate required electricity on site; air conditioning is provided by absorption chillers. Both cooling and heating are fueled by waste heat recovered from the prime movers if available, or, alternatively, by gas-fired boilers. Like the reference system, this system uses a single-duct variable-volume air-distribution system.

Table E Equipment Performance Characteristics

	<u>Coefficient of Performance (Efficiency)</u>
Electric cooling	4.40
Gas heating	0.80
Absorption cooling	0.64
Electric (resistance) heating	1.00
Electricity generation	0.34

System Energy Requirements
(as a percent of reference system)

Percent of Waste Heat Used

	<u>Heating</u>	<u>Cooling</u>	<u>Heating</u>	<u>Cooling</u>
Reheat	180%	120%	--	--
Economy	62%	62%	--	--
Central Plant	--	--	11%	74%
Total Energy	--	--	--	74%

RESIDENTIAL ENERGY CONSERVATION

Residences use energy for a variety of important day-to-day activities, and energy costs are important components of housing expenses. In 1974, New England consumers spent \$2416 million on residential energy use (excluding transportation \$1800 million). Among New England residences use of energy, space heating accounts for 70-75% of the total use, with 15% of the total used for hot water. The remaining use is divided among cooking, refrigeration, lighting and air conditioning.

There are many energy conservation measures which will not only reduce energy consumption but also save money for the consumer. As will be seen in a later section, this reduction in energy expenditures, which can be used to increase purchases and/or savings, has important economic benefits to the region. This report will identify measures which can be taken to reduce residential energy consumption, the likely costs of these measures, and the resulting overall savings in energy expenditures. We will also estimate direct employment effects in the region of adopting these measures.

Conservation Measures

Inasmuch as space heating represents the major portion of energy expenditures, the greatest potential for energy savings is to be found in reducing the heat loss of residential units. Many other energy conservation measures directed at improving the efficiency of hot water heaters, refrigerators, stoves and air conditioners are also cost-effective, though these will not be specifically addressed here. The following chart provides a rough indication of the cost effectiveness of several residential conservation measures.

COST EFFECTIVENESS OF ENERGY CONSERVATION MEASURES

	\$ per household			
	Investment Cost C	Annual Savings A	C/A	Cost Effective
1. Furnace thermostat setback	0	\$37 to \$124	0	Yes
2. Furnace tune-up	\$20/yr	gas \$8 to \$18	-	No
	\$20/yr	oil \$17 to \$38	-	Yes ^a
3. Retrofit electric ignition, gas furnaces	\$65	\$6 to \$13	5.1 to 11.1	No
4. Improve thermal integrity, existing houses	?	?	?	?
5. Electric ignition, new gas furnaces	\$20	\$6 to \$14	1.4 to 3.3	Yes ←
6. Improve efficiency, new heating plants	\$50	gas \$16 to \$34	1.5 to 3.1	Yes
	\$50	oil \$32 to \$71	< 1 to 1.6	Yes
7. Improve thermal integrity, new houses	?	?	?	?
8. Air conditioner thermostat set up	0	\$1 to \$10	0	Yes
9. Air conditioner tune-up	\$20/yr	\$1 to \$9	-	No
10. Improve efficiency, new air conditioners	\$45	room \$9 to \$17	2.7 to 5.0	No ^b
	\$95	central \$5 to \$45	2.1 to 18.0	No ^c
11. Water heater thermostat set back	0	\$9 to \$30	0	Yes
12. Reduce hot water use	0	\$6 to \$36	0	Yes
13. Improve efficiency, new water heater	\$10	\$7 to \$17	< 1 to 1.4	Yes
14. Improve efficiency, new refrigerators, freezers	\$90	refrigerator \$16	5.6	No
	\$90	freezer \$20	4.5	No
15. Electric ignition, new gas ranges	\$20	\$2	> 10	No
16. Electric ignition, new gas dryers	\$10	\$2.80	3.5	Yes

^aIn most regions at assumed prices.

^bExcept in West South Central and East South Central regions where it would be cost effective at assumed prices.

^cExcept in West South Central, East South Central, and South Atlantic regions where it would be cost effective at assumed prices.

Source - Rand, 1975

The remainder of this report will focus on the two conservation measures not addressed in the preceding chart--improving the thermal integrity (i.e. reducing heating demand) of new and existing buildings. Various measures are applicable to different types and age housing units. These measures include increased insulation of ceilings, walls, and floors, and reducing infiltration of cold outside air through storm windows and weatherstripping. (Storm windows also reduce the heat loss through windows). These measures vary across housing ages and types principally in the levels of insulation which can be adopted in a cost effective manner. This study and other previous studies indicates that there is a large potential for energy conservation through insulating New England homes.

Methodology

To determine the effect of insulation or weatherization on a housing unit, we must determine how such a measure affects the heat loss of that unit. This change in heat loss then indicates the reduction in demand for heating fuels. To estimate how conservation measures would reduce the heating demands of New England's housing stock, we used the "Residential Energy Forecasting Model" (Reform) developed by Richard Daifuku, of Brookhaven National Laboratories, and implemented on the NEEMIS computer system by John Maglio. This model simulates heat loss for prototypical New England housing units in their current state of weatherization and for various conservation improvements. Details on insulation measures for the prototypical housing units are found in the Appendix.

Impacts

For the purposes of economic impact analysis, two simple cases were selected. The first reduced energy use by approximately 20 percent--upgrade attic insulation to R-19 (six inches) minimum in all homes and weatherstrip and install storm windows on all homes. The second case reduced energy use by approximately 30 percent--basement/floor insulation of R-19 was added to the above improvements. The payback period for the first case ranges from 1.6 - 3.3 years, depending on the housing type. The payback for the second case ranges from 2 - 3.5 years. The following charts present the effects of conservation alternatives on the major housing types. The impacts of Case I and II are also shown:

Table II.8

FOCUS ANALYSIS

Single Family Detached Pre-1940 Oil-Heated Units (Uninsulated)

Option	Cost (\$/unit)	Annual BTU's Saved(10 ⁶ /unit)	\$ Value BTU's saved	Payback (Yrs.)	Net Present Value of Savings	Benefit Cost Ratio
<u>Non-weatherization</u>						
N-1 Burner Maint.	122.70*	8.6	31.20	0.4	181.20	2.5
N-2 5° Thermostat Setback	90.00	51.8	187.70	0.5	1752.70	20.5
<u>Weatherization</u>						
1 Weatherstripping	92.90	18.3	66.30	1.5	167.10	2.7
2 1 & Storm Wind- ows	239.80	28.0	101.40	2.4	436.60	2.8
3 Storm Doors**	34.00	1.0	3.60	9.4	-9.80	0.7
4 R-11 Walls	969.60	112.8	408.70	2.4	3017.00	4.1
5 R-19 Floors	270.00	20.0	72.50	3.8	436.90	2.6
6 R-19 Ceilings	270.00	57.7	209.10	1.3	1769.00	7.6
7 R-30 Ceilings	444.00	62.8	227.50	2.0	1776.00	5.0
8 R-38 Ceilings	498.00	65.2	236.20	2.1	1806.00	4.6
<u>Optimal Package</u>						
9 #2, 4, 5 & 8	1977.40	226.0	813.60	2.4	5696.50	3.9

Selection of Optimal Weatherization Investments

Money available to spend	<div> <div>Case I</div> <div>Case II</div> </div>			
	\$225-275	\$450-550	\$675-825	\$900-1100
Optimal Option or Combination	R-19 ceiling	R-19 ceiling & WS, SW	R-19 Floor + & WS, SW	R-11 Walls + & WS
Cost	270.00	509.80	779.80	1065.50
Payback	1.3	1.6	2.0	2.2
Net Present Value	1769.00	2205.60	2642.50	3184.10
Benefit-Cost Ratio	7.6	5.3	4.4	4.0
BTU's Saved	57.7	85.7	105.7	131.1

*This investment represents annual service costs of \$12.50 discounted over a 20 year period for 50% of the units.

**This assumes 100% weatherstripping already existing, which enhances storm door heat savings.

Table II.9

FOCUS ANALYSIS

Single Family Detached Pre-1940 Oil-Heated Units (Insulated)

Option	Cost (\$/unit)	Annual BTU's Saved (10 ⁶ /unit)	\$ Value BTU's saved	Payback (Yrs.)	Net Present Value of Savings	Benefit Cost Ratio
<u>Non-weatherization</u>						
N-1 Burner Maint.	122.78	6.7	24.30	0.5	114.10	1.9
N-2 5° Thermostat Setback	90.00	44.8	162.30	0.5	1503.70	17.7
<u>Weatherization</u>						
1 Weatherstripping	95.90	18.3	66.30	1.5	167.10	2.7
2 1 & Storm Wind- ows	239.80	28.0	101.40	2.4	436.60	2.8
3 Storm Doors**	34.00	1.0	3.60	9.4	-9.80	0.7
4 R-11 Walls	969.60	76.9	278.60	3.5	1748.50	2.8
5 R-19 Floors	270.00	20.0	72.50	3.1	436.90	2.6
6 R-19 Ceilings	222.00	15.2	55.10	4.1	315.30	2.4
7 R-30 Ceilings	396.00	20.4	73.90	5.4	325.00	1.8
8 R-38 Ceilings	450.00	22.7	82.20	5.5	352.30	1.8
<u>Optimal Package</u>						
9 #2, 4, 5 & 8	1929.40	147.6	531.36	3.6	2974.3	2.5

Selection of Optimal Weatherization Investments

		CASE I	CASE II	
Money available to spend	\$225-275	\$450-550	\$675-825	\$900-1100
Optimal Option or Combination	WS, SW	WS, SW & R-19 Floors	WS, SW, R-19 Floors & Ceiling	WS & R-11 Walls
Cost	239.80	509.80	731.80	1065.50
Payback	2.4	2.9	3.2	3.1
Net Present Value	436.60	873.50	1188.80	1915.60
Benefit-Cost Ratio	2.8	2.7	2.6	2.8
BTU's Saved	28.0	48.0	63.6	95.2

*This investment represents annual service costs of \$12.50 discounted over a 20 year period for 50% of the units.

**This assumes 100% weatherstripping already existing, which enhances storm door heat savings.

Table II.10

FOCUS ANALYSIS

Single Family Detached 1940-1965 Oil-Heated Units

Option	Cost (\$/unit)	Annual BTU's Saved (10 ⁶ /unit)	\$ Value BTU's saved	Payback (Yrs.)	Net Present Value of Savings	Benefit-Cost Ratio
<u>Weatherization</u>						
1 Burner Maint.	122.10*	5.1	18.50	0.7	57.50	1.5
2 5° Thermostat Setback	90.00	35.5	128.60	0.7	1172.81	14.0
<u>Weatherization</u>						
1 Weatherstripping	102.60	19.7	71.40	1.4	180.50	2.8
1 & Storm Windows	257.50	30.3	109.80	2.4	474.70	2.8
1 Storm Doors**	34.00	1.0	3.60	9.4	-9.80	0.7
1 R-11 Walls	1005.60	10.6	38.40	26.4	-631.00	0.37
1 R-19 Floors	293.00	21.5	77.90	3.8	467.00	2.6
1 R-19 Ceilings	221.30	8.4	30.40	7.3	75.50	1.3
1 R-30 Ceilings	279.90	14.1	51.10	5.5	218.50	1.8
1 R-38 Ceilings	468.00	16.7	60.50	7.8	121.50	1.3
<u>Optimal Package</u>						
#2, 5 & 7	830.40	65.9	237.24	3.5	1160.20	2.4

Selection of Optimal Weatherization Investments

Money available to spend	\$225-275	\$450-550	CASE II \$675-825	\$900-1100
Optimal Option or Combination	WS, SW	WS, SW & R-30 Ceilings	WS, SW, R-19 Ceilings & Floors	WS, SW, R-19 Floors & R-30 Ceilings
Cost	257.50	537.40	771.8	830.40
Payback	2.4	3.3	3.5	3.5
Net Present Value	474.70	693.20	1017.2	1160.20
Benefit-Cost Ratio	2.8	2.3	2.3	2.4
BTU's Saved	30.3	44.4	60.2	65.9

*This investment represents annual service costs of \$12.50 discounted over a 20 year period for 50% of the units.

**This assumes 100% weatherstripping already existing, which enhances storm door heat savings.

Table II.11

FOCUS ANALYSIS

Single Family Attached pre-1940 Oil-Heated Units (Uninsulated)

Option	Cost (\$/unit)	Annual BTU's Saved (10 ⁶ /unit)	\$ Value BTU's saved	Payback (Yrs.)	Net Present Value of Savings	Benefit- Cost Ratio
<u>Non-weatherization</u>						
N-1 Burner Maint.	122.90*	6.3	22.80	0.5	100.00	1.8
N-2 5° Thermostat Setback	90.00	37.8	137.00	0.7	1254.70	14.9
<u>Weatherization</u>						
1 Weatherstripping	74.50	14.2	51.40	1.5	129.60	2.7
2 1 & Storm Wind- ows	184.10	21.3	77.20	2.4	330.50	2.8
3 Storm Doors**	34.00	1.3	3.60	9.4	-9.80	0.7
4 R-11 Walls	568.80	66.2	239.90	2.4	1771.10	4.1
5 R-19 Floors	237.00	15.0	54.30	4.4	293.00	2.2
6 R-19 Ceilings	237.20	50.4	182.60	1.3	1544.30	7.5
7 R-30 Ceilings	390.00	54.9	198.90	2.0	1550.50	5.0
8 R-38 Ceilings	437.00	56.9	206.20	2.1	1574.20	4.6
<u>Optimal Package</u>						
9 #2, 4, 5 & 8	1426.90	159.4	573.84	2.5	3968.80	3.8

Selection of Optimal Weatherization Investments

Money available to spend	\$225-275	CASE I	CASE II	\$900-1100
		\$450-550	\$675-825	
Optimal Option or Combination	R-19 Ceilings	R-19 Ceilings & Floors, & WS	R-11 Walls & R-19 Ceilings	R-11 Walls, R- Ceilings, & WS
Cost	237.20	548.70	806.00	990.10
Payback	1.3	1.9	1.9	2.0
Net Present Value	1544.30	1966.90	3315.4	3645.9
Benefit-Cost Ratio	7.5	4.6	5.1	4.7
BTU's Saved	50.4	79.6	116.4	137.9

*This investment represents annual service costs of \$12.50 discounted over a 20 year period for 50% of the units.

**This assumes 100% weatherstripping already existing, which enhances storm door heat savings.

1985 Heating Demand 10^{12} BTU

	Ct.	Ma.	Me.	N.H.	R.I.	Vt.	N.E.
Base Case	144.1	266.07	62.32	47.58	40.03	24.62	584.72
Improvement 1	118.92	214.73	52.03	39.04	32.20	20.43	477.35
Improvement 2	103.8	185.82	45.74	35.24	27.78	18.82	416.82

Cost Millions of 1974 Dollars

	Ct.	Ma.	Me.	N.H.	R.I.	Vt.	N.E.
I							903.25
II							1243.03

If we assume that other residential energy demands are reduced in proportions similar to the above cases the following savings in residential energy bills results:

	Consumption 10^{12} BTU	Payments millions 1974 \$'s	10^6 BTU/per unit	\$per/unit
1974	634.8	\$ 2408	161.4	\$612.5
1985 Base	840.4	\$ 3814	183.4	\$832.4
1985 Case I	678.0	\$ 3041	147.9	\$663.6
1985 Case II	608.6	\$ 2701	132.8	\$589.9

As can be seen, Case I reduces New England's 1985 residential energy bill by \$773 million dollars ('74 \$'s). Case II further reduces it by a total of \$1111 million. We estimate the yearly cost of achieving these reductions is \$45.16 million for Case I and \$62.15 million for Case II. Therefore, New England consumers would have an additional \$727 or \$1048 million dollars, for Case I and II respectively, to spend in the region.

Conclusion

The above data indicates that for most New England homes, there are a number of conservation measures which can substantially lower the total energy-related costs. Furthermore, these savings are often extremely good investments as indicated by Cases I and II. Nevertheless, many homeowners remain unaware of or financially unable to adopt these measures. Steps to correct these problems can substantially mitigate the impact of rising energy prices on the average family.

CHARTS

The following charts indicate the per-unit impacts of various conservation measures. These were prepared by the Maine Energy Conservation Workshop of the Department of City and Regional Planning at Harvard University. The cost figures are for current costs (1977 \$) and savings value assume the following fuel prices:

Oil = \$0.50/gal.

Gas = \$4.00/mcf.

Electricity = \$0.03/kwh.

While the cost and value of savings are not necessarily equivalent to the New England average, they are representative of New England as a whole.

Present value calculations were done using an 8% discount rate. We believe this rate is high considering expected rates of oil price increases and current rates for home improvement loans. A more economically appropriate discount rate would fall in the 3.5 to 5 percent range. Nevertheless, even with the higher discount rate, many insulation measures show high net present values.

Appendix D
Table D.1

BTU's Saved (10^6 BTUs Per Unit)

	WS	WS,SW	SD	R-11 Walls	R-19 Floors	R-19 Ceiling	R-30 Ceiling	R-38 Ceiling
<u>SFD</u>								
65-77 E	NA	NA	NA	NA	3.5	NA	3.8	5.4
D	6.1	16.6	.6	NA	11.5	NA	7.2	10.3
40-65 D	19.7	30.3	1.3	10.6	21.5	8.4	14.1	16.7
M	16.4	25.2	.9	8.9	17.9	7.0	11.8	13.9
<40 DU	18.3	28.0	1.0	112.8	20.0	57.7	62.8	65.2
<40 MU	15.3	23.4	.8	94.0	16.7	48.1	52.4	54.3
<40 DI	18.3	28.0	1.0	76.9	20.0	15.2	20.4	22.7
<40 MI	15.3	23.4	.9	64.2	16.7	12.6	17.0	18.9
<u>SFA</u>								
65-77 E	NA	NA	NA	NA	2.3	NA	2.8	4.0
D	3.7	8.9	.5	NA	7.7	NA	5.4	7.6
40-65 D	14.3	22.0	1.0	6.1	15.4	7.0	11.9	13.9
<40 DU	14.2	21.3	1.0	66.2	15.0	50.4	54.9	56.9
<40 MU	12.5	17.7	.9	55.2	12.5	42.0	45.8	47.5
<40 DI	14.2	21.3	1.0	45.3	15.0	13.2	17.9	19.9
<u>MFLR</u>								
65-77 E	NA	NA	NA	NA	1.9	NA	2.4	3.4
D	2.2	6.9	.1	NA	6.0	NA	4.6	6.5
40-65 D	8.6	15.9	.1	3.7	12.6	6.5	11.1	13.0
<40 DU	8.6	15.9	.1	40.4	12.6	47.4	51.9	53.8
<40 DI	8.6	15.9	.1	27.5	12.6	12.6	17.3	19.2
<u>MFHR</u>								
65-77 D	15.0	29.2	.1	NA	NA	2.3	NA	NA
<u>MOBILE</u>								
E	NA	NA	NA	NA	5.04	3.6	NA	NA
D	8.7	12.5	1.0	NA	9.6	6.86	NA	NA

Appendix D
Table D.2

\$ VALUE OF BTU'S SAVED (\$ PER UNIT)

	WS	WS,SW	SD	R-11 Walls	R-19 Floors	R-19 Ceiling	R-30 Ceiling	R-38 Ceiling
<u>SFD</u>								
65-77 E	NA	NA	NA	NA	30.32	NA	33.40	47.47
D	21.96	59.76	2.16	NA	41.40	NA	25.92	37.08
40-65 D	70.92	109.08	4.68	38.16	77.40	30.24	50.76	60.12
M	63.47	97.52	3.06	34.44	69.24	24.09	45.66	53.79
<40 DU	65.88	100.80	3.6	406.08	72.0	207.72	226.08	234.72
<40 MU	59.21	90.56	2.72	363.78	64.63	186.15	202.79	210.14
<40 DI	65.88	100.80	3.6	276.84	72.0	54.72	73.44	81.72
<40 MI	59.21	90.56	3.06	248.45	64.63	48.76	65.79	73.14
<u>SFA</u>								
65-77 E	NA	NA	NA	NA	20.22	NA	24.61	35.16
D	13.32	32.04	1.8	NA	27.72	NA	19.44	27.36
40-65 D	51.48	79.20	3.6	21.96	55.44	25.20	42.84	50.04
<40 DU	51.12	76.68	3.6	238.32	54.0	181.44	197.64	204.84
<40 MU	48.38	68.50	3.0	213.62	48.38	162.54	177.25	183.83
<40 DI	51.12	76.68	3.6	163.08	54.0	47.52	64.44	71.64
<u>MFLR</u>								
65-77 E	NA	NA	NA	NA	16.70	NA	21.09	29.88
D	7.92	24.84	.36	NA	21.60	NA	16.56	23.40
40-65 D	30.96	57.24	.36	13.32	45.36	23.40	39.96	46.80
<40 DU	30.96	57.24	.36	145.44	45.36	170.64	186.84	193.68
<40 DI	30.96	57.24	.36	99.00	45.36	45.36	62.28	69.12
<u>MFHR</u>								
65-77 D	54.0	105.12	.36	NA	NA	11.52	NA	NA
<u>MOBILE</u>								
E	NA	NA	NA	NA	44.26	31.64	NA	NA
D	31.32	45.0	.36	NA	34.44	24.70	NA	NA

Appendix D
Table D.3

COST (\$ PER UNIT)

	WS	WS,SW	SD	R-11 Walls	R-19 Floors	R-19 Ceiling	R-30 Ceiling	R-38 Ceiling
<u>SFD</u>								
65-77 E	NA	NA	NA	NA	273.70	NA	289.80	346.0
D	149.80	380.10	34.0	NA	297.85	NA	289.80	346.0
40-65 D	102.62	257.54	34.0	1005.6	292.95	221.34	279.93	468.0
M	102.62	257.54	34.0	1005.6	292.95	221.34	279.93	468.0
◀40 DU	95.90	239.80	34.0	969.6	270.00	270.00	444.0	498.0
◀40 MU	95.90	239.80	34.0	969.6	270.00	270.00	444.0	498.0
◀40 DI	95.90	239.80	34.0	969.6	270.00	222.00	396.0	450.0
◀40 MI	95.90	239.80	34.0	969.6	270.00	222.00	396.0	450.0
<u>SFA</u>								
65-77 E	NA	NA	NA	NA	201.96	NA	213.84	255.0
D	81.95	203.4	34.0	NA	219.78	NA	213.84	255.0
40-65 D	76.25	188.5	34.0	574.80	244.80	184.96	233.92	391.0
◀40 DU	74.53	184.06	34.0	568.80	237.15	237.15	389.98	437.0
◀40 MU	74.53	184.06	34.0	568.80	237.15	237.15	389.98	437.0
◀40 DI	74.53	184.06	34.0	568.80	237.15	194.99	347.82	395.0
<u>MFLR</u>								
65-77 E	NA	NA	NA	NA	174.42	NA	184.68	220.0
D	61.54	159.08	4.25	NA	189.81	NA	184.68	220.0
40-65 D	61.54	159.08	4.25	347.40	230.85	174.42	220.59	369.3
◀40 DU	61.54	159.08	4.25	347.40	230.85	230.85	379.62	425.0
◀40 DI	61.54	159.08	4.25	347.40	230.85	189.81	338.58	384.0
<u>MFHR</u>								
65-77 D	59.06	206.87	1.28	NA	NA	36.18	NA	NA
<u>MOBILE</u>								
E	NA	NA	NA	NA	244.80	432.0	NA	NA
D	55.30	139.10	42.50	NA	244.80	432.0	NA	NA

APPENDIX D
TABLE D.4

PAY BACKS (YEARS)

	WS	WS,SW	SD	R-11 Walls	R-19 Floors	R-19 Ceiling	R-30 Ceiling	R-38 Ceiling
<u>SFD</u>								
65-77 E	NA	NA	NA	NA	NA	NA	8.7	7.3
D	6.8	6.36	15.74	NA	NA	NA	11.2	9.3
40-65 D	1.4	2.4	7.26	26.4	26.4 3.8	7.3	5.5	7.8
M	1.6	2.6	11.11	29.2	29.2 4.2	8.2	6.1	8.7
<40 DU	1.5	2.4	9.44	2.4	2.4	1.3	2.0	2.1
<40 MU	1.6	2.6	12.5	2.7	2.7	1.5	2.2	2.4
<40 DI	1.5	2.4	9.44	3.5	3.5	4.1	5.4	5.5
<40 MI	1.6	2.6	11.11	3.9	3.9	4.5	6.0	6.1
<u>SFA</u>								
65-77 E	NA	NA	NA	NA	12.0	NA	10.5	8.7
D	6.2	6.5	18.88	NA	7.9	NA	11.0	9.3
40-65 D	1.5	2.4	9.44	26.2	4.4	7.3	5.5	7.8
<40 DU	1.5	2.4	9.44	2.4	4.4	1.3	2.0	2.1
<40 MU	1.5	2.7	11.11	2.7	4.9	1.5	2.2	2.4
<40 DI	1.5	2.4	9.44	3.5	4.39	4.1	5.4	5.5
<u>MFLR</u>								
65-77 E	NA	NA	NA	NA	12.6	NA	10.53	8.9
D	7.8	6.4	11.80	NA	8.8	NA	11.2	9.40
40-65 D	2.0	2.8	11.80	26.1	5.1	7.5	5.52	7.9
<40 DU	2.0	2.8	11.80	2.4	5.1	1.4	2.03	2.2
<40 DI	2.0	2.8	11.80	3.5	5.1	4.2	5.44	5.6
<u>MFHR</u>								
65-77 D	1.1	2.0	3.55	NA	NA	4.4	NA	NA
<u>MOBILE</u>								
E	NA	NA	NA	NA	5.53	13.7	NA	NA
D	1.8	3.1	11.80	NA	7.11	17.5	NA	NA

Appendix D
Table D.5

NET PRESENT VALUE (\$ PER UNIT)

	WS	WS,SW	SD	R-11 Walls	R-19 Floors	R-19 Ceiling	R-30 Ceiling	R-38 Ceiling
<u>SFD</u>								
65-77 E	NA	NA	NA	NA	23.98	NA	38.13	120.10
D	-62.12	20.89	-19.50	NA	108.62	NA	-35.31	18.06
40-65 D	180.50	474.70	-9.85	-6.31	467.00	75.50	218.50	121.50
M	150.80	396.83	-9.85	-667.46	387.15	44.63	168.37	60.12
<40 DU	167.14	436.58	-9.85	3017.00	436.00	1769.00	1776.00	1806.00
<40 MU	140.51	367.86	-13.27	2602.4	364.55	1557.65	1547.02	1565.19
<40 DI	167.14	436.58	-9.85	1748.46	436.00	315.25	325.09	352.34
<40 MI	140.51	367.86	-13.27	1469.72	364.55	256.73	249.93	268.01
<u>SFA</u>								
65-77 E	NA	NA	NA	NA	-3.43	NA	27.78	90.21
D	-28.76	11.59	-21.92	NA	52.38	NA	-22.97	13.62
40-65 D	129.29	342.94	-15.21	-359.19	299.52	62.46	186.69	100.36
<40 DU	129.58	330.47	-9.85	1771.06	293.03	1544.29	1550.48	1574.15
40 MU	118.64	275.58	-10.65	1528.55	237.85	1358.69	1350.29	1367.87
40 DI	129.58	274.73	-9.85	1032.34	293.03	271.57	284.86	308.37
<u>MFLR</u>								
65-77 E	NA	NA	NA	NA	-10.46	NA	22.38	74.35
D	-29.92	7.60	-1.83	22.26	NA	NA	-22.09	9.74
40-65 D	62.07	225.00	-1.83	-216.62	214.50	55.32	171.74	90.50
<40 DU	62.07	225.00	-1.83	1080.59	214.50	1444.52	1454.80	1476.58
40 DI	62.07	225.00	-1.83	624.59	214.50	255.54	272.89	294.63
<u>MFHR</u>								
65-77 D	156.55	498.49	1.14	NA	NA	76.92	NA	NA
<u>MOBILE</u>								
E	NA	NA	NA	NA	189.75	-121.35	NA	NA
D	69.71	162.85	-18.34	NA	93.34	-189.49	NA	NA

SFD - Single Family Detached
SFA - Single Family Attached
MFLR - Multi Family Low-Rise
MFHR - Multi Family High Rise

E - Electric
D - Distillate
M - Methane--Natural Gas
U - Uninsulated
I - Insulated

1985 Inventory (1,000's)

	<u>SFD</u>	<u>SFA</u>	<u>MFLR</u>	<u>MFHR</u>	<u>MOBILE</u>
1972-85 _e	191	93	55	13	<div style="display: flex; align-items: center;"> <div style="flex: 1; border-left: 1px solid black; border-right: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; right: -10px; font-size: 2em;">}</div> <div style="position: absolute; bottom: 0; right: -10px; font-size: 2em;">{</div> </div> <div style="margin-left: 10px;"> e=21 d=188 </div> </div>
_____d	379	172	117	25	
_____m	100	79	20	8	
1965-72 _e	81	46	15	6	
_____d	125	70	23		
_____m	37	21	6		
1940-65 _d	546	154	24		
_____m	162	46	7	d=79	
Pre-1940 du	151	201	69	m=23	
_____mu	45	59	21		
Pre-1940 di	505	167	86		
_____mi	<u>150</u>	<u>50</u>	<u>26</u>		
Total	2472	1158	469	157	209

SURVEY OF NEW ENGLAND BUSINESSES

INTRODUCTION

As part of the NEEPA study this researcher, Rena Kallman, conducted a survey of firms in selected business categories in the six New England states, the object of which was to identify perceptions among firms as to the seriousness of the fuel cost and availability situation. The basic premise was that firms would act according to these perceptions, engaging in programs to mitigate any unfavorable effects of fuel prices upon operating costs and upon competitive survival. If firms perceived their situation as serious and were not acting, it was assumed that obstacles had blocked their attempts to act. ✓

The survey results show that although 71% of respondents had energy cost increases of at least 50% since the energy shortage began, only about one-fourth of all participants had implemented high-cost energy saving measures. Only two firms said their efforts had actually lowered energy costs. The most common measure taken to reduce energy consumption was a cutback in usage for heat, which was followed closely by cutbacks for lighting. Such measures are under the heading "House-keeping" and do not generally involve projects requiring major capital investments.

One reason for the lack of extensive investment in consumption-reduction projects appears to be the lack of an obvious reduction in the market shares of New England firms. 30% said there was no change in market share due to energy prices; 48% didn't know if there had been a change; only 20% experienced a decrease in share; and one firm claimed to have had an increase. Only 13.5% of respondents said that energy costs had caused no net change in prices charged to customers. The remaining 86.5% of the firms had been able to pass on the costs by raising prices for their products.

The conclusion from the market share and price data is that few firms have felt constrained by competition to bear the energy costs internally. There is no indication, however, as to how long firms can continue to pass on costs without experiencing a noticeable change in market share.

In a ranking of seven concerns facing the firm, energy costs were deemed important, a close second to labor costs. Energy availability, however, was ranked seventh, which is surprising if one thinks in terms of natural gas usage in the region. 40% of the firms use gas for heating and one-third use gas for processing, yet only 6% of firms responding ranked energy availability as a first or second concern. Only 5 firms use gas as the sole source of heat or processing fuel, yet none of these five ranked availability in first or second place. The availability situation, it seems, has not yet become evident to New England business, as none have experienced cutoffs up to this point. The apparent availability of the fuel for an indefinite period provides a reason for gas users not to embark upon projects to improve their fuel supply position.

The most frequently mentioned obstacles to the attainment of energy conservation goals were inadequate technical information, the uncertainty as to future facilities requirements, and the absence of a firm government policy. In followup interviews it was learned that some firms resist entering into energy projects because of uncertainties as to future energy needs, prices and regulations

do not enable them to estimate a return on investment. Other firms are presently committed to pollution projects and cannot absorb further investment. There is some indication also that energy-related projects have not yet reached the top of the priority scale in competition for a firm's resources, even where potential cost savings can be proven.

In general, it appears as though most firms have taken some steps in the direction of reducing relative energy consumption. Firms interviewed mentioned that in replacing plant or equipment, energy efficiency was a main consideration in acquisition decisions. For some firms this concern with energy economy has been an ongoing consideration since well before the oil embargo; for others it was clearly a new phenomenon.

The survey and followup have uncovered several issues having policy implications. The results suggest that further dialogue with firms in the region would be profitable in order to clarify such matters as what financial obstacles, if any, the business community is facing with regard to energy project funding. In addition, we ought to suggest policy alternatives and solicit reactions to these from business firms.

About This Survey

This survey, conducted by anonymous questionnaire, was intended to provide the Energy Policy Office with information useful in developing business energy strategies. Areas to be determined were: the extent to which major energy consuming industries have been hit by the fuel situation; ways in which managements have mitigated the effects of high prices and/or short supply; how competitive positions have been altered relative to firms outside New England. It was believed that actual dollar or percentage changes in fuel costs and supplies were not so important as perceived changes in these. The original premise was that if firms perceived the situation as extremely adverse, they would be driven to shut down, or if feasible, to relocate outside the region. Either alternative would have serious economic implications for New England.

In selecting firms, there was no attempt to include only those companies which were conceivably in a position to relocate. The choice of industries was based on several factors:

1. Whether the industry was local mainly to New England (e.g., jewelry)
2. Whether the industry was "typical" to New England (data from Price Waterhouse's New England Business: Profile and Analysis, and companion report New England Business: Financial and Statistical Information, prepared for the New England Regional Commission, September, 1976.)
3. Whether the industry consumed significant quantities of energy, based upon a pre-determined measure of energy-intensiveness. (This criterion basically limited the study to manufacturers, as opposed to, say, retailers.)

The actual choice of firms depended in part upon sales volume and in part upon the number of people employed. Firms were not chosen simply because they were big, but hopefully because they were "typical", as determined with the help of the Price Waterhouse study and the Directory of New England Manufacturers. Some exceptions were made, however, in the inclusion of a few firms which are not particularly typical to the region but are major national companies which just happen to be located here in New England.

Since the process of selection depended neither on the type of fuel used (which was not discovered until responses were received), nor on whether firms were in a position to expand or relocate, the issue of location did not play a major role in the survey, and only a few speculative interpretations of the data have been made.

In addition to the location question, certain other issues not treated in the survey emerged as survey results were analyzed. Since a few firms chose not to remain anonymous, and three participants actually contacted the Energy Policy Office expressing further interest in our survey, we conducted a few in-depth interviews in which these other issues were treated. Included were questions such as:

- What are the firm's priorities for investment decisions?
- Do you take energy consumption decisions into account when making plans for expansion of plant facilities?
- Would you expand in New England? (Why or Why not?)
- Do you still have low-cost options available to you for cutting back energy consumption?

- What would lead you to implement or avoid certain energy-related investments if you knew they would save you money?

Some interesting observations can be made from the results of these interviews, which will be reported following the discussion of the questionnaire results.

Generally speaking, although the survey accomplished goals slightly different from the location-related aims originally specified, it provided an extremely useful picture of how New England firms are experiencing the energy crisis.

In interpreting the results, the responses for each particular state will not be treated as any sort of statistical sample for that state. The choice of firms was intended more as a regional profile than a state-by-state profile. Therefore, although responses have been tallied by state, the results for Connecticut, for example, do not necessarily reflect the way firms in Connecticut experience the energy situation so much as they reflect the way particular types of manufacturers, many of which happen to be located in Connecticut, view the energy situation.

In order to achieve the regional profile mentioned above, the number of firms selected was supposed to roughly approximate the breakdown of New England based businesses reported in the Price Waterhouse study (New England Business: Profile & Analysis, Exhibit A-5).

<u>State</u>	<u>Actual %</u>	<u>Survey %</u>
Massachusetts	47.8	46.5
Connecticut	24.8	16.6
Rhode Island	8.4	8.0
Maine	8.3	15.8
New Hampshire	6.8	9.6
Vermont	3.9	3.5
TOTAL NEW ENGLAND	100%	100%

The reason Maine's percentage is out of proportion to the regional breakdown is related to the voluntary cooperation of the Maine Energy Policy Office in helping us conduct this survey. Robert Radcliffe of that office suggested a number of firms for study that would otherwise have been overlooked, and the number of firms surveyed in other states was not then changed to reflect the addition.

One problem in choosing a proportionate but small number of firms for inspection is that the actual response significantly modifies the intended breakdown by state and by industry type. The results reported, therefore, work with the revised breakdown of firms and in no way reflect the original breakdown.

We were generally pleased with the number of responses received, which is broken down as follows:

	<u>Sent</u>	<u>Received</u>	<u>% Response</u>
Massachusetts	53	41	77%
Rhode Island	9	7	77
Maine	18	12	66
New Hampshire	11	6	54
Vermont	4	2	50
Connecticut	<u>19</u>	<u>6</u>	<u>31</u>
TOTAL NEW ENGLAND	114	74	65%

The questionnaires were coded by state in order to permit segregated analysis of the data. Otherwise the survey was anonymous, with identification of firms by name not essential to our purposes. Brief descriptions of products per Question #15 enabled us to classify firms according to industry.

Roughly broken down by two-digit SIC Codes, the responding firms belong to the following industries:

	<u>MA</u>	<u>ME</u>	<u>VT</u>	<u>RI</u>	<u>CT</u>	<u>NH</u>	<u>TOTAL</u> <u>NE</u>
20 Dairy	2						2
Processed Foods		1					1
22 Textiles		4					4
Coated Fabrics	2						2
23 Wearing Apparel					1		1
24 Lumber	2	2	1				5
Wood Products	1					1	2
25 Furniture: Wood	3						3
Metal	1						1
26 Paper Products	1		1				2
30 Rubber Products	1				1		2
Misc. Chemical/Plastics	2				1		3
31 Shoes, Leather	6	2					8
32 Abrasives, Concrete	4						4
34 Iron & Steel Forgings	1	1					2
Valves	1						1
Castings, Stampings		1		1			2
35 Machine Tools					1		1
Electronic Computers						1	1
Bearings	1					1	2
Specialized Machinery	3						3
36 Electronic Equip.	4	1			1	1	7
Ind. Electrical Mach.	1			1			2
Chromatography						1	1
37 Transportation Equip.					1		1
39 Jewelry		1			4	1	6
Silverware		2					2
Toys		1			1		2
Misc. Mfg.		1					1
TOTALS	<u>41</u>	<u>12</u>	<u>2</u>	<u>7</u>	<u>6</u>	<u>6</u>	<u>74</u>

QUESTIONNAIRE RESPONSES

Question #1. The first question refers to sources of fuel and is intended to provide a framework for analyzing Questions 2-11, regarding the cost and availability of fuel and the competitive position of the firm.

<u>Results by % of Responses</u>	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
<u>Fuel Usage for Heating:</u>							
Oil	35	6	5	11	6	2	65
Natural Gas	22	4	3	1			30
Electricity	11	2		1	1		15
Other: wood/waste	3			2			5
steam	2						2

Fuel Usage for Manufacturing Processes

Oil	20	6		9		1	36
Natural Gas	16	1	3	3	1		24
Electricity	30	5	4	9	5	2	55
Other: wood/waste	3			2			5
steam	2						2
propane	1	1					2
hydrogen	1						1

Question #2. In this question firms are asked to rank energy costs and energy availability in relation to other problems that may confront the firms. From these data one should be able to determine where energy issues stand in the priorities of New England businesses. Apparently there is some connection between the ranking of energy costs and whether a firm takes action to mitigate costs. Energy costs were ranked second overall in this survey, and only four firms failed to check any items under Question #12, "Actions that have been taken," indicating that perception of a problem generally led to corrective action.

When firms are broken down by size and type, the issue of priorities and rank ordering appears in a different context. Large firms (those employing more than 750 people) may have ranked energy costs as item #4 or #5, since other issues such as labor costs, OSHA regulations and/or corporate taxes have a more serious impact on their survival. Yet energy costs were an important enough priority to command attention and action, as indicated in the response to Question #12.

In other cases, the type of firm made a difference in the interpretation of the ranking. For most firms in the survey, EPA Regulations were given low priority, but the opposite was true in the case of lumber and paper firms. In these industries EPA Regulations were ranked nearer the top and energy costs followed closely behind. Apparently there are special problems relating to the use of woodwaste as a source of energy which would make the lumber industry a good candidate for a separate study.

For the sake of a raw ranking of scores, the data can be broken down by state as follows:

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
MA	Energy Costs	Labor Costs	Corporate Taxes	Property Taxes	OSHA Regs.	EPA Regs.	Energy Availability
CT	Labor Costs	Corporate Taxes	Energy Costs	OSHA Regs.	Property Taxes	Energy Avail.	EPA Regs.*6
RI	Corporate Taxes	Labor Costs	Energy Costs	Energy Avail.	Property Taxes*4	OSHA Regs.	EPA Regs.
ME	Labor Costs	Energy Costs	Corporate Taxes	Property Taxes	OSHA Regs.	EPA Regs.	Energy Avail.
NH	Energy Costs	Labor Costs	EPA Regs.	OSHA Regs.	Property Taxes	Corporate Taxes	Energy Avail.
VT	Energy Costs	EPA Regs.	OSHA Regs.*2	Corporate Taxes*2	Energy Avail.	Labor Costs	Property Taxes*6

*6 Indicates tie, and for which place

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

ALL NEW NEW ENGLAND STATES

ASSIGNING RANK

<u>RANK</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>		
<u>ITEM</u>								<u>TOTAL * POINTS</u>	<u>% POSSIBLE POINTS</u>
ENERGY COSTS	16	19	16	10	5	5		373	75%
LABOR COSTS	21	21	7	8	6	4	3	369	75.3
CORPORATE TAXES	14	12	11	9	14	3	6	315	65
PROPERTY TAXES	2	10	15	14	7	10	10	256	54
OSHA REGULATIONS	8	2	5	11	19	17	7	235	48
EPA REGULATIONS	8	3	6	9	9	12	21	212	44
ENERGY AVAILABILITY	2	2	9	7	9	17	21	181	38

<u># OF USERS:</u>	<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
Heating	30	65	15	7
Processing	24	36	55	10

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

Massachusetts

ASSIGNING RANK

<u>RANK</u>	<u>ITEM</u>	<u># RESPONDING TO ITEM</u>	<u>POSSIBLE # POINTS *</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>TOTAL * POINTS</u>	<u>% POSSIBLE POINTS</u>
	Energy Costs	39	273	10	10	9	6	3	1		210	77%
	Labor Costs	38	266	11	11	5	6	2	1	2	202	76
	Corporate Taxes	38	266	7	6	9	5	6	3	2	176	66
	Property Taxes	37	259	1	8	6	8	4	5	5	144	55
	OSHA Regulations	38	266	3	1	4	4	15	5	6	124	46
	EPA Regulations	37	259	5	2	2	4	5	9	10	116	44
	Energy Availability	36	252	2		3	5	3	12	11	93	37

<u># OF USERS:</u>	<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
Heating	22	35	11	5
Processing	16	20	30	7

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

Connecticut

ASSIGNING RANK

<u>RANK</u> <u>ITEM</u>	<u># RESPONDING</u> <u>TO ITEM</u>	<u>POSSIBLE #</u> <u>POINTS *</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>TOTAL *</u> <u>POINTS</u>	<u>% POSSIBLE</u> <u>POINTS</u>
Energy Costs	6	42	1	1		2	1	1		26	62%
Labor Costs	6	42	4	1				1		36	85
Corporate Taxes	6	42		4		1	1			31	74
Property Taxes	6	42			3		1	1	1	21	50
OSHA Regulations	6	42	1			2	1	2		22	52
EPA Regulations	6	42			1	1	1	1	2	16	38
Energy Availability	6	42			2		1		3	16	38

<u># OF USERS:</u>	<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
Heating	4	6	2	0
Processing	1	6	5	1

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

Rhode Island

ASSIGNING RANK

<u>RANK</u>	<u>ITEM</u>	<u># RESPONDING TO ITEM</u>	<u>POSSIBLE # POINTS *</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>TOTAL * POINTS</u>	<u>% POSSIBLE POINTS</u>
	Energy Costs	6	42		2	1	2		1		27	64%
	Labor Costs	6	42	1	2	1		2			30	71
	Corporate Taxes	6	42	4			1	1			35	83
	Property Taxes	6	42		1	3			1	1	24	57
	OSHA Regulations	6	42	1			1		3	1	18	43
	EPA Regulations	6	42				1		1	4	10	24
	Energy Availability	6	42		1	1	1	3			24	57

OF USERS:

<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
3	5	0	0
3	0	4	0

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

Maine

ASSIGNING RANK

<u>RANK</u> <u>ITEM</u>	<u># RESPONDING</u> <u>TO ITEM</u>	<u>POSSIBLE #</u> <u>POINTS *</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>TOTAL *</u> <u>POINTS</u>	<u>% POSSIBLE</u> <u>POINTS</u>
Energy Costs	12	84	1	4	5		1	1		63	75%
Labor Costs	12	84	3	5	1	2	1			67	80
Corporate Taxes	12	84	3	2			4		3	48	57
Property Taxes	12	84	1	1	1	4	1	3	1	44	52
OSHA Regulations	12	84	2		1	2	1	6		42	50
EPA Regulations	12	84	2		1	2	2	1	4	39	46
Energy Availability	12	84			3	1	2	2	4	33	39

<u># OF USERS:</u>	<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
Heating	1	11	1	2
Processing	3	9	9	2

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

RANKING OF ITEMS IN TERMS OF IMPORTANCE TO THE FIRM

New Hampshire

#	ASSIGNING RANK
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
32	32
33	33
34	34
35	35
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98	98
99	99
100	100

<u>RANK</u>	<u># RESPONDING TO ITEM</u>	<u>POSSIBLE # POINTS *</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>TOTAL * POINTS</u>	<u>% POSSIBLE POINTS</u>
ITEM											
Energy Costs	6	42	2	2	1			1		33	78%
Labor Costs	6	42	2	2			1	1		30	71
Corporate Taxes	5	35			1	1	2		1	16	46
Property Taxes	5	35			2	2			1	19	54
OSHA Regulations	5	35	1			2	1	1		20	57
EPA Regulations	5	35	1	1	1		1		1	22	63
Energy Availability	5	35						3	1	8	23

<u># OF USERS:</u>	<u>GAS</u>	<u>OIL</u>	<u>ELECTRICITY</u>	<u>OTHER</u>
Heating	0	6	1	
Processing	1	0	5	

Weighted total: 7 points for each ranking as #1, 6 for a rank of #2, 5 for a rank of #3, etc.

Question #3 and Question #4. These questions are intended to give some idea as to firms' perception of fuel availability for heating and for manufacturing. No temporal basis for judgment was provided in the wording of these two questions, so firms seem to have assumed we were referring to the immediate present. Considering the fact that the following question, #5, indirectly asks the same question about availability in the immediate future (next few years), the respondents were justified in their interpretation of the third and fourth questions.

<u>Availability of fuels for heating</u>	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
More than adequate	4	1		1			6
Adequate	35	4	6	11	6	2	64
Less than adequate	2	1	1				4

Availability of fuels for
manufacturing processes

More than adequate	4	1					5
Adequate	30	4	6	12	6	2	60
Less than adequate	6	1					7
No response	1		1				2

Of the firms that felt energy sources were more than available, two use wood-waste only, two use oil only, and two use oil in combination with other fuels. Overwhelmingly, however, it appears that firms are not suffering from a shortage of fuel supplies at the present. These results are consistent with the last-place ranking of energy availability.

Question #5. This question was designed to provide another approach to the topic of availability. If firms were not concerned about present availability, it would be useful to know how seriously they were responding to national reports of fuel shortages expected in the next few years. It is not clear that Question #5 satisfied its objective, however. What is missing is the rationale behind the firm's answer to the question.

Consider, for example, that there is more than one reason for answering "yes" to the question. The responses were supposed to provide us with a measure of how many firms believed long-term availability was no problem. In addition to affirmative responses from these firms, there may be several more firms who responded "yes" because they don't believe they have any choice in the matter. It may be that they use a fuel which is very expensive (oil, electricity) or which they believe to be in short supply (natural gas), but they don't see any alternatives given their resources, their long-term uncertainties regarding plant capacity, or for that matter, uncertainties regarding prices of substitute fuels.

At the other extreme are firms responding negatively to the question. Is it for price or availability reasons that firms intend to switch? Which fuels do they expect to discontinue? With what do they wish to replace them?

The question also does not enable the interpreter to decide whether or not the respondent has actually given much thought to the availability problem. Since energy availability was ranked last overall in Question #2, it is possible that the problem has not even come under consideration for many firms. Such firms would be inclined to answer "yes" to Question #5 without much hesitation.

Here are the results for Question #5, "Do you feel that you will continue to use the same sources of energy over the next few years?"

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Heating:							
yes	37	5	7	8	6	1	64
no	3	1		3		1	8
don't know	1			1			2
Manufacturing:							
yes	36	6	6	9	6	1	64
no	2			1		1	4
don't know	3		1	1			5

Question #6. The question dealing with competitors was intended to aid in the interpretation of Questions #7,8 and 10, in which competitive issues were discussed. Unfortunately, few clear conclusions can be directly drawn from the data about competitor location. For instance, some firms whose competitors we know to be in New England (because the competitors were included in the survey) did not list New England as a competitor location.

Another problem with interpreting competitor location data lies in the fact that this researcher is not in a position to determine that a firm with a Midwestern competitor, for example, is in a better or worse energy price/availability situation than that competitor. We do not know what source of fuel or level of technology the competitor is using.

For all intents and purposes, the most meaningful conclusions can be drawn about the firms listing only New England as the seat of competition (13 firms). These firms would presumably be less motivated by competitive factors, since competitors should suffer from the same geographic disadvantages. Even in terms of firms competing only with other New Englanders, however, there is no basis for the assumption that there is no competitive disparity among firms in the same region. Indeed, a dairy firm we interviewed believes its competition to be strictly New England based, and that firm's top priority for investments is "projects that will enable us to remain competitive."

Results from Question #6

<u>Competitor Location</u>	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL NE</u>
New England	22	2	6	7	6	1	44
Mid-Atlantic States	17	2	4	2	3	1	29
Southeastern U.S.	8	3	1	6			18
Southern U.S.	7	2	1		1		11
Midwest	17	5	3	1	1	2	29
Northwest	2			2			4
Southwest	4	1			1		6
Pacific Coast	8	2	3		1		14
Canada	1			1			2
overseas	8	3	2	1	2		16

Question #7. This question deals with the availability of fuel as compared with competitors' availability. 85% of the respondents answered that fuel sources were at least as available to them for their operations needs as to competitors. Of the six firms for whom sources were less available to them than to competitors, four were firms in the lumber business, for reasons which are not clear. As mentioned before, a detailed study of the lumber industry is beyond the scope of this paper, but should prove instructive. As for the majority who believe themselves to be no worse off than competitors, there is no clear pattern to indicate the locations of competitors to whom they refer.

Sources of energy for the firm as compared with competitors' sources.

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL NE</u>
At least as available to me for my needs as to competitor for his needs.	32	5	5	12	6	1	61
Less available to me than to my competitors	4		1			1	6
Don't know	3	1	1				5

Question #8. As far as fuel costs are concerned, here again we have no true measure of comparison between a firm and its competitors. If firms had intended to imply that their fuel costs were only higher than those of firms located outside New England, they would presumably have checked option #4. However, 27 firms chose option #1, which implies that even within the region their competitors have a cost advantage. Of these 27 firms which believe their costs to be higher than those of (unspecified) competitors (option #1), about half indicated that they had taken only "housekeeping" types of conservation actions, such as heat, lighting and air-conditioning cutbacks, or no action at all.

In keeping with our intention to deal with perceptions, it should be noted that the results of this question imply a preceived competitive disadvantage on the part of more than half of the respondents (options #1 and #4 taken together). Of respondents who chose option #4, more than half had not taken action beyond house-keeping, as was the case with those who checked option #1. If half of the firms studied perceive a competitive disadvantage, there must be other reasons for them not to take action. These reasons are explored in Question #13, and even more fully in the followup interviews.

The results of Question #8 are as follow:

In comparison with your competitors, do you believe your energy costs to be:

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Higher than theirs	17		3	6	1		27
Same as theirs	15	2	2	2	4	1	26
Lower than theirs*	1			1			2
Only higher than those of competitors outside NE.	7	3	1	2		1	14
Don't know	1	1	1	1	1		5

* Both firms reporting costs lower than competitors' costs were users of woodwaste as fuel.

Question #9. The results of this question should in some way correlate with the ranking of Energy Costs in Question #2. Indeed, the largest number of respondents (53) had increased costs of more than 50%. Only 19 firms had increases of 0-50%, and two firms managed to lower their costs. These two firms are both in the electronic components business, one in Maine and one in Connecticut. Both are oil users for heat and manufacturing, and neither has implemented high cost energy-saving measures. While the reasons for their success are not quite apparent, these firms have demonstrated that businesses can do a proper job of energy cost-reduction without high-cost investment.

The interpretation of the results of Question #9 is somewhat guarded because there is no attention given to the subject of production capacity. Raw energy expenditure may have increased due to increased consumption, while efforts in the same company to cut back wasteful use of energy may have actually mitigated the effect of energy prices. The firm has seen a rise in energy expenditure, but not necessarily due only to increased prices.

The firm's costs have:	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Increased 0-50%	12	1	2	2	2		19
Increased 50-100%	20	2	3	4	2	1	32
Increased over 100%	9	2	2	5	2	1	21
Decreased due to conservation		1		1			2

Question #10. This question represents another way of determining a perceived competitive disadvantage. Indeed, the firms who responded that energy prices had caused a decrease in the firm's market share were found to have responded that energy costs had risen at least 50% (Question #9) and that energy costs were higher for them than for their competitors (Question #8). In most cases, firms were unable to attribute a market share change to energy prices, however.

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Decrease in market share	13		1	1			15
No change in market share	10	1	2	6	3		22
Increase in market share	1						1
Don't know if energy was related to a change in market share.	16	5	3	5	3	2	34
Don't know if market share has changed at all	1		1				2

Question #11. Presumably, most firms have raised their prices since 1973. This question asks respondents to determine whether or not the price increases were specifically related to energy prices. 87% of respondents attributed the change in prices to the energy crisis. It is reasonable to assume that costs passed on by suppliers have been considered by the respondents who chose alternative #1 for this question. Of the 10 firms who responded that energy prices did not increase product prices, 6 firms were involved in metals industries, 3 were producers of electronic components and equipment, and one was a manufacturer of shoe lasts. It is assumed that these ten firms were relatively unaffected by energy costs on the whole, or else were somehow externally prevented from raising prices.

Results of Question #11: Energy prices have helped to cause overall:

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Increases in customer prices	38	5	4	10	4	2	63
No net change in prices	2	1	3	2	2		10
Decreases in customer prices							0
No response	1						1

Question #12. The firm has nine options in the question, and may fill in as many as apply. The first three measures are simple cutbacks in energy used for controlling facilities' environment. The options listed should reflect a progression in order of degree of commitment and effort. The question is really intended to mean, "How far have you progressed in your efforts to cutback energy consumption?" Presumably, efforts should progress from simple cutbacks, to proposals for more complex actions, to consultation with experts, through to the actual implementation of energy saving measures.

The action that was the least frequently mentioned in the survey was, "exploration of possible money sources to finance energy-related improvements. That result led to the hypothesis that firms were more interested in using internally generated funds to finance internal projects (such as low-cost energy-saving measures, and perhaps even the high-cost measures), than in using debt financing. The in-depth interviews shed a bit more light on the subject.
(Chart on following page)

Action:	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE*</u>
1. Heating cutback	35	6	4	10	5	1	61
2. Lighting cutback	33	5	3	8	4	1	54
3. Cooling cutback	25	4	4	3	4		40
4. Maintenance improvements	29	3	2	7	4	1	46
5. In-house proposals	24	4	4	4	2	1	39
6. Consultation with experts	22	4	1	5	3	1	36
7. Exploration of financing	6			3		1	10
8. Low-cost measures	23	5	1	6	4	1	40
9. High-cost measures	13	1	1	3		1	19
All nine	1						1
All except #7	5						5
All except #3	1					1	2
All except #9	2						2

* Five firms did not respond to Question #12

Question #13. This question was designed to provide some clue as to the factors which prevent or impede the implementation of energy-related projects. Unfortunately, in eleven out of thirty cases in which no difficulties were listed, firms had taken little or no action under Question #12. On the other hand, firms which had made considerable efforts to reduce energy consumption were quick to point out the many difficulties they had encountered.

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
Lack of financial support	4	1					5
Inadequate technical info.	12	1	1	4	1	1	20
Future uncertainties	11	2	2	2		2	19
No difficulties	15	2	4	5	5		30
Other difficulties	8	1		1			10

Some comments from participants about "other difficulties."

- "My landlord controls the heat." (This statement leads to a new topic for study - firms that have no control over essential energy costs.)
- "Environmental problems"
- "Central Massachusetts Air Pollution Control" (preventing firms from adopting wood-burning process).
- "EPA Regulations make wood-burning cost-prohibitive"
- "Need accurate forecasting of the availability of various fuels in five-year increments for the next 25 years."
- "Lack of National Energy Policy. Assurance of availability of supply is essential to our continued operation, as natural gas cannot be substituted for in our production operations because of metallurgical requirements."
- "Government action uncertain as to fuels available to industry and long-range availability of coal."
- "Air pollution restrictions for conversion to use of coal."
- "Unable to cost-justify conversion to wet-bark process."

Question #14. Was lack of financial support due to the fact that the project was energy-related? It was hoped that this question would provide information as to whether discrimination against energy projects was occurring among lending institutions. Since most firms appeared to prefer internal generation of cash, or to assume the money had to come from internal sources, there is inadequate data about the financial obstacles to improvement provided by this survey.

Total response was:

2 "no" from Maine

1 "no" from New Hampshire

1 "yes" from Connecticut

The respondent replying "yes" to this question may be speaking for many firms with his comment, "It appears that a continuing high charge for energy is more acceptable than the capital charge to reduce energy costs."

Questions 15, 16, 17 were intended to provide a means of categorizing respondents while keeping the firms anonymous. With the list of products given by the firm, we were enabled to classify responses by gross SIC codes and to produce industry profiles.

The size of the firms studied ranges from 16 to 5000.

	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL</u> <u>NE</u>
16-50	4		2		3	1	10
51-100	7		2	1			10
101-250	9	1	2	3		1	16
251-500	5			1			6
501-750	5			2			7
751-1000	3			5			8
1001-3000	5	4	1		2		12
3001-5000	3	1			1		5

The market data in Question #17 were intended to help identify firms that were more or less tied to a New England location by the location of their market. Even if these firms were less competitive in terms of energy expenditures, it was reasoned, they'd have to either stay here or carve out brand new markets elsewhere. The third alternative would be to relocate the plant outside the region and ship the goods back here. There is not enough information to provide any picture of differential costs involved, but it stands to reason that the firm near its market would have a distributional advantage in staying here.

A firm with a diversified market would have several other options open to it. The firm could totally or partially relocate. Management might want to remain here but build all expansion outside the region. The firm might want to adjust marketing and distribution strategies to cut costs. There is no data directly in this survey to bring about any clear conclusions as to how market location and energy decisions are related; more emphasis on this topic might have been appropriate had firms indicated strong dissatisfaction with fuel availability in their responses, or provided stronger evidence that energy costs were creating a competitive disadvantage. In the two questions relevant to the topic of competitive disadvantage (#8 and #10), only 14 and 15 firms respectively chose the alternatives which bear out its existence, and there is no information here in the survey to shed light on the possible distributional advantages which compensate for high operating costs. In short, conclusions from the market data are highly speculative.

<u>New England Market</u>	<u>MA</u>	<u>CT</u>	<u>RI</u>	<u>ME</u>	<u>NH</u>	<u>VT</u>	<u>TOTAL NE</u>
0-15% of total	22	4	4	5	4		39
16-30%	4	1		2		1	8
31-45%	2						2
46-60%	5					1	6
61-75%	1		1	2			4
76-90%	2		1	1			4
91-100%	4			2	2		8
don't know	1	1	1				3

INDUSTRY PROFILES

1. Jewelry Companies

There were seven firms in this category responding to the survey. The typical company uses oil or gas for heat, and gas or electricity for processing. The company has under 200 employees, and only a small portion of its market is New England. This last is to be expected, as New England is the major jewelry producing section in the country. The typical jewelry firm has experienced energy cost increases of over 50%, and believes its competitors have similar energy problems. In all cases, firms expect to continue with the same fuels as are now used. Energy cost and availability are generally at the top of the list of concerns, however. There is no typical pattern of action taken, as firms' responses range from cutback in heat only, to all measures taken except for air-conditioning cutback. (It is conceivable that the facilities are not air-conditioned). Typically the firm has raised its prices in response to increased costs, but is not aware of any market share change specifically related to energy. The firm encounters obstacles in the nature of inadequate technical information and uncertainties as to future requirements.

2. Rubber and Plastics Firms

For these firms, New England typically constitutes less than 51% of the market. Competitors are believed to be located in several parts of the country and energy costs are felt to exceed competitors' costs. The firm in the rubber and plastics industry uses oil for heat and processing, and expects to continue using the same fuels as are now in use. Fuel costs have increased at least 50%, and the firm has typically taken actions for housekeeping improvement and implementation of low-cost measures. Availability of fuels is felt to be the same for the New England firm as for its competitors. Uncertainties as to future requirements pose an obstacle for this firm's energy program.

3. Textile Industry

The typical textile firm has over 600 employees and sells about 20% of its goods in New England. Oil is used for heating, and manufacturing operations consume oil and electricity.

Competitors are located in the Southeastern U.S. They probably face the same situation as to fuel availability ("adequately available"), but fuel costs are higher in New England, having increased about 100% since the fuel crisis began.

The typical textile firm has made high-cost improvements for the sake of reduced energy consumption or increased efficiency. The high-cost measures were in addition to low-cost improvements.

4. Lumber Industry

This industry has a slightly different profile from those firms previously discussed, because of the prevalence of woodwaste as a fuel source. Over half of the lumber firms in the survey use woodwaste in some form.

Firms burning sawdust and woodwaste are worried about energy costs, but are even more worried about EPA regulations. The firms in which fuel costs have increased are those in which some other conventional fuels are used in addition to the wood. All firms have increased the prices charged to customers, however. Firms are divided as to whether they will continue to use the same energy source. The indication is that they would prefer to use all wood, but are restricted from doing so.

Competition exists throughout the U.S. and in Canada, and availability appears to be the same for competitors as for New England firms (which was to be expected). Cost differences cannot be clearly determined, but the costs of compliance with rules may have varying effects on the responses. Typically firms do not know whether energy has had an effect on market share.

5. Profile of a Typical Firm Implementing High-Cost Measures

The typical firm uses oil for heat, but usually in combination with some other fuel for both heating and processing. Energy costs are not the #1 problem for the firm. For this company New England constitutes less than 25% of the market, and competitors are located in at least one other part of the country.

Energy availability is at least adequate, probably more than adequate at present. The firm expects to continue using the same sources of fuel over the next few years. In spite of willingness to undertake high-cost projects, there is no expectation that a switch in fuels will be one of these projects.

Fuel is felt to be at least as available to the firm as to its competitors. Although fuel costs have risen at least 50% and customer prices have had to increase, the firm doesn't know whether or not there has been a change in market share.

Because of sheer scale (the typical firm in this category has over 700 employees), these firms probably experienced greater pressure from escalating costs and were also more able to devote expenditures to energy projects. Generally, firms felt a competitive disadvantage from high energy prices in New England, and this perception probably was the motivation for their high-cost actions. The results imply that energy costs would have been far higher for the firm, in the long or short-run, had no high-cost projects been undertaken.

The firm's representative indicated that the facilities are now able to handle substitution of fuels. The plant can use interruptible gas, for instance, and boiler conversion to coal is feasible. But, he said, the heartache comes from the unpredictability involved. Business does not know what the future rules will be, and must try to outguess the federal government, the state government and the market in its attempt to plan ahead.

Two other firms interviewed reiterated the problem of outguessing future rules. All three indicated that what they feared was learning that an operations site had been reclassified by the EPA after considerable energy related investment had been made. One firm begged for some system whereby original site approval could not be withdrawn by the EPA.

One of the firms cooperating in the followup pointed out another reason for the hesitation involved in energy projects. This company is already committed to long-term municipal water-pollution projects which are funded through a program of subordinated debt. This firm does not foresee the acceptance of more debt and cannot generate funds for energy projects internally at this point.

All firms interviewed indicated that energy consumption plays a part in decisions of plant and equipment acquisition, though not necessarily an overriding part. Firms would be reluctant to retire a piece of equipment "early" for the sake of acquiring a more efficient machine. When equipment is ready for retirement, however, energy is one of the factors studied in the replacement decision. Labor and productive capacity would tend to be more important factors, nonetheless.

As for plant acquisition, firms indicated that they would expand outside of New England, and in fact have already done so. Energy was one among many factors entering into their decision. The exception to location outside the region is the one respondent, with 5000 employees, for whom all facilities and personnel, and 90% of the market, are located in New England.

One of the firms in the followup summarized by stating that all the company's decisions are based on economics. Only in the case of immediate need is Return on Investment disregarded, he said. It can be inferred that most firms studied are more closely similar to this last firm than to the firm which has been able to experiment with non-returning projects and those with longer payback.

In light of the above, it is fitting for this paper to end with questions rather than answers.

- Will energy cutoffs and skyrocketing prices be required before the state of "immediate need" is reached?
- What sorts of prices and "certainties" will be needed before the payback of energy projects reaches an acceptable level?
- How will firms cope with the lead time required when and if the state of "immediate need" is reached?
- How can energy-related investments be demonstrated to be equal to investments enabling the firm to stay competitive?

RESULTS OF FOLLOW-UP INTERVIEWS

The question of investment priorities is interesting, as these priorities may actually constitute an obstacle to energy projects. One firm interviewed listed its investment priorities as follows:

1. Projects that enable us to remain competitive
2. Projects that are of a must do nature as dictated by Environmental and OSHA Regulations
3. Those that generate economic savings to lower our costs
4. Those that contribute to energy conservation

It is not apparent that Priority #4 is any different from Priority #3. In the case of a firm whose competitors are well situated with energy, it is not even clear that energy issues are different from those listed as Priority #1. The question now becomes: Why would firms avoid making the connection between energy conservation, saving money and remaining competitive?

A different firm explained the issue this way: There is so much uncertainty as to future fuel prices and availability that a major investment in energy projects is not guaranteed to save money in the long-run, nor even to enable them to remain competitive. They might be able to adopt new manufacturing processes which reduces fuel consumption, but they could not make such a change unless they could avoid unforeseen or undesirable effects in other parts of the system. In other words, high cost changes are not easily made simply for the sake of reduced consumption of energy. Savings must be clearly demonstrable.

One large New England firm (5000 employees) described the nature of their energy program to us. The firm has been concerned with minimizing fuel consumption for several years. In some ways this firm might be said to have few energy options left to it because their efforts began well before costs escalated. Since 1973, however, the firm has been able to save over \$1 million through energy projects. One low-cost improvement in the efficiency of boiler use saved \$80,000.

The firm consumes large quantities of oil, natural gas and electricity in operations, and will embark upon projects with payback periods that are longer than normal simply in order to ensure fuel supply. The company generates its own investment capital and has been able to experiment with energy projects which do not necessarily involve a dollar return, merely for the sake of the experiment (e.g., a solar heat project). The company's representative conceded that most firms are not in a position to make changes and conduct experiments so readily.

This large firm has increased fuel consumption in operations over the past few years, and one of its new processes actually uses more energy than the process it replaced, for production of an improved product. Even though production and consumption have increased, however, energy efficiency has also increased, as consumption has not been rising as quickly as production.

NEW ENGLAND REGIONAL ENERGY OFFICE SURVEY

Kindly answer all of the following questions and return the survey in the envelope provided. Your responses will be kept strictly confidential. Thank you.

1. What sources of fuel are used by the firm for:

a. Heating

_____oil
_____natural gas
_____electricity
_____specify other (_____)

b. Manufacturing Processes

_____oil
_____natural gas
_____electricity
_____specify other(_____)

2. Please rank the following items, from 1 to 7, in terms of their importance as problems for the firm. (1 is most serious problem of those listed, 7 is least.)

_____ OSHA Regulations
_____ Corporate Taxes
_____ Property Taxes
_____ Energy Availability
_____ Energy Costs
_____ Labor Costs
_____ EPA Regulations

3. Do you believe that your present sources of energy for heating are:

_____ more than adequately available
_____ adequately available
_____ less than adequately available

4. Do you believe that yours present sources of energy used for manufacturing operations are:

_____ more than adequately available
_____ adequately available
_____ less than adequately available

5. Do you feel that you will continue to use the same sources of energy over the next few years?

Heating: _____yes _____no _____don't know

Manufacturing: _____yes _____no _____don't know

6. Major competitors are located in: (check as many as apply)

<input type="checkbox"/> New England	<input type="checkbox"/> Midwest	<input type="checkbox"/> Pacific Coast
<input type="checkbox"/> Mid-Atlantic States	<input type="checkbox"/> Northwest	<input type="checkbox"/> overseas
<input type="checkbox"/> Southeastern U.S.	<input type="checkbox"/> Southwest	<input type="checkbox"/> not sure
<input type="checkbox"/> Southern U.S.		

7. Do you feel that sources of energy are:

☐ at least as available to you for your operations needs, as
to your competitors for their needs
☐ less available to you than to your competitors
☐ no idea

8. Do you believe your energy costs to be:

☐ higher than those of your competitors
☐ about the same as those of your competitors
☐ lower than those of your competitors
☐ only higher than those of your competitors located outside
New England
☐ don't know

9. Over the past three years, since the energy shortage, the firm's
total energy costs have increased: (approximately)

☐ 0-50% ☐ 50-100% ☐ over 100%
☐ efforts to save energy have actually lowered energy costs

Please continue with questions on reverse----->

10. New England energy prices alone, in your estimation, have
accounted for:

☐ a decrease in the firm's market share
☐ no change in the firm's market share
☐ an increase in the firm's market share
☐ don't know if energy prices have caused any market share change
☐ don't know if market share has changed at all for any reason

11. Energy prices have helped to cause overall

☐ increases in prices charged to customers
☐ no net change in prices that was related to energy
☐ decreases in prices charged to customers

12. Check those of the following actions that have been taken:

☐ cutback in energy usage for heating
☐ cutback in energy usage for lighting
☐ cutback in energy usage for air-conditioning/cooling
☐ improvements in routines, or frequency, of maintenance

(Question 12, cont.)

- ☐ in-house proposals submitted for other energy-conservation measures
- ☐ consultation with experts (e.g., engineers)
- ☐ exploration of possible money sources to finance energy-related improvements
- ☐ actual implementation of low-cost energy-saving measures
- ☐ implementation of high-cost energy-saving measures

13. Have you encountered obstacles in attaining energy-conservation goals? (check as many as apply)

- ☐ lack of support from financial sources
- ☐ inadequate technical information as to available alternatives
- ☐ uncertainties as to future requirements (e.g., plant size, capacity)
- ☐ no difficulties
- ☐ other difficulty(specify) _____

14. If the obstacle was lack of financial support, do you believe that difficulty was due to the fact that the project was energy-related?

☐ yes ☐ no ☐ to some extent

If 'yes' or 'to some extent' please explain

15. Please list briefly the types of products you manufacture in New England?

16. Number of employees employed in New England _____

17. What percentage (approx.) of your market is New England? _____%

18. Other Comments.

appendix II

The Economic Impact of Energy Policies on the Wood Furniture and Metalworking Equipment Industries in New England

Prepared for
**The Commonwealth of Massachusetts
Energy Policy Office**

By
**Harbridge House, Inc.
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December 1977



Boston New York Washington Chicago Denver Los Angeles London Frankfurt am Main

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EXECUTIVE SUMMARY

Project Purpose and Scope

This study estimates "the economic impacts on selected New England Industries of changes in energy prices, changes in energy price structures (e.g., electricity rate structure), and governmental energy conservation programs. [Its] overall goal is to determine the ability of industry to react to, or take advantage of, energy-related changes in the business environment." (Contract Work Statement.)

The industrial groups studied are--

Wood Household and Office Furniture (SIC 251/2)

Metal Working Machinery and Equipment (SIC 354)

The time frame for the study is 1974-1985.

Conclusions Derived Through Field Survey and Analysis

1. Projected increases in the price of energy will have little impact on New England manufacturers' marketing competitiveness over the period--

- New England energy sources are thought to be more secure than those of competitive regions in the South and Midwest. This provides a competitive advantage.
- Pass-through pricing can offset price increases.

2. Incentives to invest in energy-conserving projects currently are few--

- Energy costs contribute a small amount to the cost of manufacture (for example, 1-5 percent).
- Labor charges contribute 10 to 25 times more to the cost of manufacture than do energy costs.
- Given a limited investment budget, the tendency is to invest in labor-saving machinery, rather than in energy-conserving plant, machinery and equipment.

3. Until full-employment production levels are reached, increases in shipment orders will tend to increase, rather than decrease the energy intensity of manufacture--

- Underutilized hourly workers can respond to incremental demand through increased use of power-driven machinery.
- Adjustment of manufacturing shifts to 'off-peak' hours of energy use is generally infeasible. Wage differentials are such that a 10 percent electricity rate reduction covers no more than 2-5 percent of added labor costs.

4. The opportunities for further rehabilitation of plant to promote energy conservation are viewed as being limited--

- 40-50% of the building structures used by SIC 251/2 and 354 manufacturers are seen to be obsolete and unsuitable for energy conserving investment.
- However, except in large, multi-plant firms, there is a shortage of staff specifically assigned to identify and evaluate energy-conserving opportunities.

5. During the period 1974-1977, energy conserving activities were initiated up to a financially reasonable limit--

- Capital investments, plus the initiation of energy saving programs, changed the price elasticity of energy demanded (E_D) by large plants to -0.36 in the Wood Furniture Industry, and to -0.09 in the Metal Working Equipment Industry. (An E_D of -1.00 would keep energy costs constant.)
- 1977-1985 projections for these two segments provide E_D 's of -0.39 and -0.16 respectively. In average annual terms, 1977-1985 E_D in large Wood Furniture plants will be -0.05/ year, rather than -0.12 as in 1974-1977. The E_D prospect for large Metal Working plants is more stable: -0.02/ year for 1977-1985, compared with -0.03/ year in 1974-1977.

6. Governmental assistance could increase the extent of energy conservation in the two industries--

- Technical assistance could help extend identification of energy-conserving investment opportunities.

- Financial assistance could make these investments feasible.

7. If governmental assistance is introduced, energy conservation at an incremental rate of 1.25%/year may be attained. This would equal a saving of 600,000 barrels of oil in the two subject industries alone--

- Without governmental assistance, the aggregate 1977-1985 E_D for New England plants of all sizes is projected at -0.37 (SIC 251/2), and -0.49 (SIC 354).
- With governmental assistance, aggregate E_D measures are projected at -0.49 (SIC 251/2), and -0.55 (SIC 354).¹

¹ Because of a large refusal rate in responding to survey questionnaires, the foregoing estimates were developed through structural and extrapolative, rather than ROI, techniques. The methods used are described in Appendix I.

I. INTRODUCTION

A. Project Scope and Purpose

Since 1974, conservation programs in New England's larger furniture manufacturing plants have reduced by 12 percent, the value of energy used to make each dollar's worth of furniture. Managers of the larger metalworking plants have introduced programs decreasing energy use in their factories by two percent. The 1974-1977 reductions in the energy-intensity of manufacture are presented graphically in Exhibit I.

Exhibit I plots 1974-1977 percentage changes--of energy costs on the vertical axis, and of energy consumed per dollar of output on the horizontal. It shows that heat, power and light usage has diminished through the substitution of cheaper for more expensive types of energy source, and accomplishment of energy-conservation projects.

Exhibit II projects the same industrial groups' energy usages to 1985. Furniture manufacturers will continue to economize on the use of electricity and fuels. But instead of reducing energy demands by the 1974-1977 average of four percent per year, demand rates will decline, on average, at only six-tenths of one percent. Metalworking manufacturers will diminish their energy usage at a four-tenths of one percent annual rate, rather than at the seven-tenths of a percent rate which obtained during 1974-1977.

Exhibits I and II partially satisfy the research objectives of the project reported below. These objectives are to determine, for New England manufacturers of Wood Household and Office Furniture (SIC 251/2) and of Metal Working Machinery and Equipment (SIC 354).

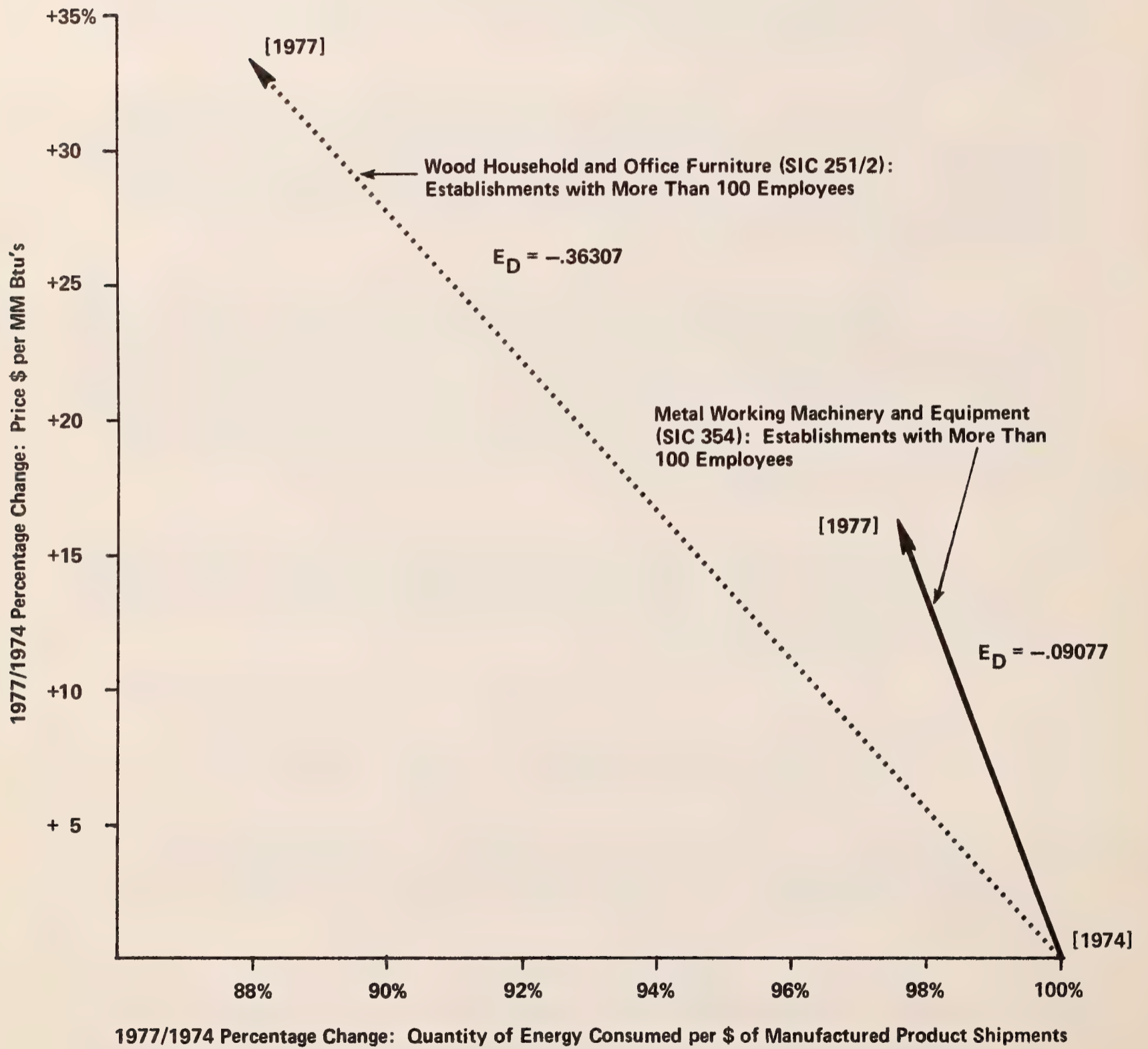
1. The elasticity of demand for energy during the period since 1974;¹
2. The capital stock and technology currently, or prospectively in use;

¹The price elasticity of demand (E_D) measures the sensitivity of quantities demanded (Q), to changes in price (P), over time ($t-1, t$). Formally, E_D is defined as

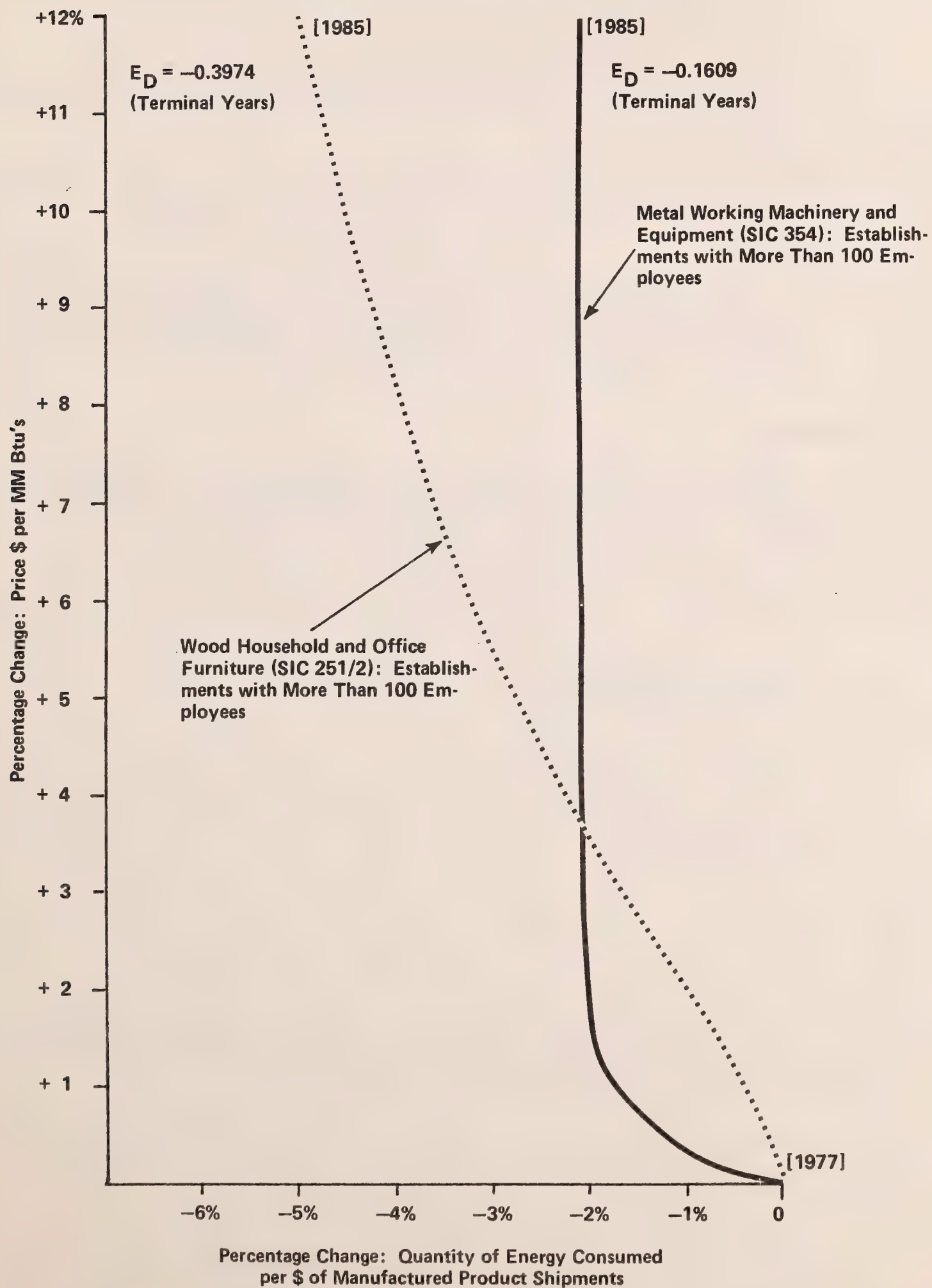
$$E_D = \frac{Q_t - Q_{t-1}}{P_t - P_{t-1}} \times \frac{P_{t-1}}{Q_{t-1}}$$

The analytic procedures used in preparing Exhibits I and II are discussed in Appendix I.

EXHIBIT I
1974/1977 CHANGES IN THE USE OF ENERGY FOR
MANUFACTURING BY NEW ENGLAND FIRMS



**EXHIBIT II
PROJECTED ELASTICITY OF DEMAND FOR
ENERGY BY NEW ENGLAND FIRMS**



3. How rates of energy usage may be expected to change over the period 1977-1985, given anticipated increases in the price of electricity and fuels;
4. How certain government policies may influence the extent to which energy conservation is achieved over the 1977-1985 period; and
5. Whether changes in New England energy costs--either absolutely, or relative to other geographic regions--will significantly affect the competitive position of New England manufacturers of wood furniture and metal working equipment through 1985.²

B. Sources of Data

New England has 476 plants which manufacture Wood Household and Office Furniture. Twelve hundred Metal Working Machinery and Equipment establishments are listed (Exhibit III). The percentage distributions of these plants (Exhibits IV and V) were used as the basis for a field survey effort made up of three components:

1. Interviews lasting one to four hours were held at a total of 16 plants within the region.
2. An additional 74 establishments were surveyed by telephone;
3. Mailed questionnaires were distributed to each of the 74 telephone respondents.³

² Appendix II presents elements of the contracted Scope of Work carried out by Harbridge House and the Center for Resource Management under contract to the Commonwealth of Massachusetts Energy Policy Office.

³ Subjects covered in site visits and by questionnaire are included as Appendices III-V.

EXHIBIT III
1976 POPULATION OF NEW ENGLAND MANUFACTURING ESTABLISHMENTS:
WOOD HOUSEHOLD AND OFFICE FURNITURE (SIC 251/2);
METAL WORKING MACHINERY AND EQUIPMENT (SIC 354)

Wood Household and Office Furniture (SIC 251/2)

Location Employees	ME	NH	VT	Northern Tier	MA	CT	RI	Southern Tier	$\Sigma \Sigma$
1-20	24	21	21	66	132	75	3	210	276
21-100	7	10	10	27	83	32	12	127	154
101-500	4	8	6	18	15	10	0	25	43
501-1,000	0	0	1	1	2	0	0	2	3
> 1,000	0	0	0	0	0	0	0	0	0
Total	35	39	38	112	232	117	15	364	476

Metal Working Machinery and Equipment (SIC 354)

1-20	7	41	18	66	260	408	30	698	764
21-100	13	16	2	31	119	127	54	300	331
101-500	1	3	5	9	20	29	6	55	64
501-1,000	0	1	3	4	5	11	0	16	20
> 1,000	0	1	0	1	6	13	1	20	21
Total	21	62	28	111	410	588	91	1,089	1,200

Source: Directory of New England Manufacturers, 1977.

EXHIBIT IV
 PERCENTAGE DISTRIBUTION OF NEW ENGLAND MANUFACTURING
 POPULATION* AND OF SAMPLE SURVEYED:
 WOOD HOUSEHOLD AND OFFICE FURNITURE (SIC Code 251)

Location # of Employees	A. <u>New England Manufacturing Population</u>		B. <u>Sample Surveyed</u>	
	Northern Tier	Southern Tier	Northern Tier	Southern Tier
21-100	14%	64%	15%	58%
101-500	9	13	13	12
501-1000	Neg.	Neg.	0	2
> 1000	0	0	0	0
Σ	23%	77%	28%	72%
				100%
				73%
				25
				2
				0

6

N = 200 firms

[An additional 276 firms are listed as having fewer than 21 employees]

N = 40 firms

[An additional 5 firms were surveyed which have less than 21 employees.]

* Firms listed as having more than 20 employees.

Source: Directory of New England Manufacturers, 1977.

EXHIBIT V
 PERCENTAGE DISTRIBUTION OF NEW ENGLAND MANUFACTURING
 POPULATION* AND OF SAMPLE SURVEYED:
 METALWORKING MACHINERY AND EQUIPMENT (SIC CODE 354)

Location # of Employees	A. <u>New England Manufacturing Population</u>	
	Northern Tier	Southern Tier
21-100	7%	68%
101-500	2	13
501-1000	1	4
> 1000	Neg.	5
Σ	10%	90%
		Σ
		75%
		15
		5
		5
		100%

N = 436 firms

[An additional 764 firms are listed as having fewer than 21 employees.]

* Firms listed as having more than 20 employees.

Source: Directory of New England Manufacturers, 1977.

B. Sample Surveyed

	Northern Tier	Southern Tier	Σ
	17%	59%	76%
	2	16	18
	2	2	4
	0	2	2
	21%	79%	100%

N = 41 firms

[An additional 4 firms were surveyed which have less than 21 employees.]

Through the field survey, data were compiled on (i) the plant, equipment and energy used by Northern and Southern Tier manufacturers during 1974-1977; (ii) the energy conserving options which wood furniture and metal working manufacturers perceive as being available; (iii) manufacturing performance records, and information on managerial decisions regarding capital investment.⁴

Supplementary materials were acquired through secondary data gathering from published sources, industry associations and governmental offices. Moreover, the literature was searched for materials on energy-conserving machinery and equipment. This search was supplemented by telephone inquiries to cited manufacturers.

While the plant visits and telephone surveys were carried out in the numbers specified above, better than 75 percent of the sample proved unable or unwilling to provide quantitative data on all of the following subjects for the years 1974-1977--

- Value of shipments
- Number of units shipped
- Capacity utilization
- Percentage distribution of manufacturing costs
- Amount of energy used, by type (for example, electricity KWH; barrels of # 6 Oil)
- Price of energy consumed, by type
- Capital investment budgeting criteria.⁵

⁴In carrying out the field research, attention was given to the possibility that New England-based firms might respond to the energy conservation objective differently from firms whose corporate headquarters are in other regions of the country. Since no appreciable difference was found, this subject is not discussed in the text.

We did find that multi-plant companies are likely to be more active in conducting energy conservation projects than are single establishments. This is discussed in Section III.C. of the text.

⁵Reasons for formal refusal to respond were of three types. (1) Requested data are proprietary. (2) Corporate reporting systems do not assemble data in the requested form. (3) Comparable types of data are already submitted in one or another form to governmental agencies (for example, the form FEA U524-P-O).

This condition was unfortunate, for the project's small sample could yield highly reliable statistical results only if a large percentage of respondents furnished complete information packages. Moreover, weaknesses in the data base precluded use of standard return on investment (ROI) analytic procedures for predicting energy-conservation projects. ROI-based forecasts of energy conservation investments were to have been used in projecting price elasticities in the demand for electricity and fuels.

C. The Final Analytic Plan

The response-rate problem was overcome by building composite profiles of similar firms. This procedure yielded an analytic base which permits "order of magnitude" estimation of conditions faced by New England's wood furniture firms and metal working equipment manufacturers. The composite profiles are too gross, however, to permit fully differentiated analysis of Northern and Southern Tier firms, or of each of the employment-size classifications presented in Exhibits IV and V.

Use of composite profiles has argued for presentation of many of the exhibits in this report as percentage distributions, rather than in strict additive form. The data arrays included below must be viewed as reflections of informed judgment operating on a statistically inexact sample. While we do not claim absolute validity for our data base, we nonetheless believe the results are sufficiently accurate to support the major behavioral and operational conclusions reported below.⁶ These bear on the prospects for further energy-conservation in the manufacture of the general product lines listed in Exhibit VI.

⁶ Future research into the prospects for industrial energy conservation may provide more exact results if the following conditions are satisfied:

1. Analytic requirements are carefully reviewed in advance, to determine whether surrogate data elements--already collected and reported--may be used in place of certain of the survey data elements developed through reference to abstract analytic models;
2. An extensive information program is carried out amongst prospective respondents prior to the survey. Ideally, the information program might lead to formal cooperation and/or participation by relevant industry associations;
3. Survey pre-testing is fully carried out;
4. Survey respondents are given approximately six weeks to fill in quantitative data forms;
5. A substantial amount of time and funds is reserved to permit follow-up calls and site visits, as relevant.

None of these conditions could be satisfied in the research described herein, which necessarily had to be constrained to a project duration of 30 to 60 days (later extended due to tardy questionnaire returns), and to a budget of approximately \$20,000.

EXHIBIT VI
PRODUCTS MANUFACTURED BY SURVEYED FIRMS

SIC 251: Household Furniture

- SIC 2511: Wood Household Furniture, Except Upholstered
- SIC 2512: Wood Household Furniture: Upholstered
- SIC 2515: Mattresses and Bedsprings
- SIC 2517: Wood Television, Radio, Phonograph and Sewing
Machine Cabinets
- SIC 2519: Household Furniture, Not Elsewhere Classified

SIC 252: Office Furniture

- SIC 2521: Wood Office Furniture

SIC 354: Metalworking Machinery and Equipment

- SIC 3541: Machine Tools, Metal Working Types
- SIC 3542: Machine Tools, Metal Forming Types
- SIC 3544: Special Dies and Tools, Die Sets, Jigs and Fixtures,
and Industrial Molds
- SIC 3545: Machine Tool Accessories and Measuring Devices
- SIC 3546: Power Driven Hand Tools
- SIC 3547: Rolling Mill Machinery and Equipment
- SIC 3549: Metalworking Machinery, Not Elsewhere Classified

Source: Standard Industrial Classification Manual, 1972.

Data-base problems also inhibited projection of the extent to which conservation projects may affect the price elasticity of demand for energy over 1977-1985. Unconventional analytic procedures were employed to circumvent data lacks. These procedures are detailed in Appendix I, Sections B-D.

One of the characteristics of the derived analytic procedure deserves comment at this point. The method tends to overstate the magnitude of energy-conserving activities which will take place early in the projected future. This shortcoming is apparent in Exhibit II's portrayal of rather dramatic reductions in the quantity of energy demanded, as prices rise the first three percentage points from 1977 levels.

II. CONDITIONS INHIBITING INVESTMENT IN ENERGY-CONSERVATION PROJECTS

Three central conditions largely explain why New England wood furniture and metal working firms are unlikely to pursue intensive energy conservation programs in future--unless supplies become short, prices rise very rapidly, or some form of institutional constraint on energy use is imposed.

1. Energy costs contribute a relatively small amount to the cost of manufacture. Exhibit VII indicates that energy costs are proportionately highest for small firms. This is due, in part, to the relatively large amount of the total energy bill which must be used to provide plant heat, light and environmental services.⁷ Moreover, small firms often are less technologically efficient than their larger competitors.

Energy's cost as a percentage of total manufacturing cost appears to decline as production scale grows toward a total plant employment of 500. Thereafter, energy efficiency once again declines in a relative sense.

2. Labor costs contribute such a large percentage to the cost of manufacture, substitution of energy-intensive machinery for labor can lead to substantial improvement in productivity levels. Exhibit I shows that the price per BTU unit acquired from a (changing) mix of electricity, oil, and natural gas rose close to 33 percent for wood furniture manufacturers, and slightly more than 15 percent for metal working equipment manufacturers, during the period 1974-1977.⁸ During the same period, the hourly wage of production workers in the two industries rose about 24 percent.⁹

⁷ "Environmental services" refers particularly to those energy uses required for compliance with EPA and OSHA regulations.

⁸ Our survey results indicate that New England manufacturers in the metal working equipment industry are more heavily dependent on electricity as a heating source than are wood furniture manufacturers. This factor helps explain Exhibit I's differential rates of BTU price increase. Also important is the considerable amount of electricity which is consumed for process heat in metal working (See Exhibit IX, below).

While electricity often is more expensive than oil or gas as an energy source, since 1974 electricity price increases have been relatively less great than have those for gas and oil. Consequently, the furniture industry has been more affected by recent changes in energy costs.

⁹ The Bureau of Labor Statistics give national hourly wage averages as follows:

	<u>1974</u>	<u>1977 (August)</u>
SIC 251	\$3.30	\$4.11
SIC 354	5.18	6.43

EXHIBIT VII
"ORDERS OF MAGNITUDE" OPERATING DATA, 1976

Number of Employees Item		1-20		21-100		101-500		> 500	
		Dollars	Percent of Shipments Value	Dollars	Percent of Shipments Value	Dollars	Percent of Shipments Value	Dollars	Percent of Shipments Value
I. <u>Wood Household and Office Furniture (SIC 251)</u>									
1.	Value of Shipments	\$500,000	100.0%	\$1,300,000	100.0%	\$7,000,000	100.0%	\$12,000,000	100.0%
2.	Cost of Sales and Operating Expenses:	--	N/A	--	N/A	--	N/A	--	N/A
	Materials Related	\$150,000	30.0		40.0		40.0		45.0
	Labor Related	\$300,000	60.0		40.0		40.0		43.0
	Total Energy	\$ 22,000	4.4	41,600	3.2	112,000	1.6	216,000	1.8
II. <u>Metalworking Machinery and Equipment (SIC 354)</u>									
1.	Value of Shipments	\$325,000	100.0%	\$1,000,000	100.0%	\$7,000,000	100.0%	\$35,000,000	100.0%
2.	Cost of Sales and Operating Expenses:	--	N/A	--	N/A	--	N/A	--	N/A
	Materials Related	\$121,875	37.5	\$ 375,000	37.5	\$2,625,000	37.5	\$14,400,000	40.0
	Labor Related	\$130,000	40.0	\$ 400,000	40.0	\$2,800,000	40.0	\$16,200,000	45.0
	Total Energy	\$ 12,350	3.8	\$ 21,000	2.1	\$ 112,000	1.6	\$ 684,000	1.9

N/A: Not Applicable

Source: Survey questionnaires.

Even despite the fact that production labor costs have recently grown more rapidly than energy costs in the metal working equipment industry, inspection of Exhibit VII's data array indicates that--for both furniture and metal working--control of manufacturing costs can best be achieved through labor-saving, energy-intensive production. Exhibit VIII's reconstitution of the previous exhibit's data brings this point into sharp detail.

3. Production well below capacity permits any increase in orders to be satisfied through more energy-intensive manufacture by the current work force, rather than through expansion of the labor component. Survey respondents were exceedingly reluctant for the most part to provide information on capacity utilization. While a few managers said their plants were operating at rates better than 80 percent of capacity, a more typical response was that capacity utilization was no greater than 35-45 percent.¹⁰

Observation during plant tours left members of the project team impressed by the number of production workers who appeared to be engaged in manufacturing operations no more than part-time. From this, we infer that so long as an effective labor surplus continues to exist within the two industries, this work force will be able to meet increases in shipment orders by using in-place machinery at a more energy-intensive rate.

Additional factors seem likely to increase the energy-intensity, rather than energy-conservation, of New England manufacturing in our two subject industries.

4. Increased market demand for upholstered furniture, rather than for casegoods, has led to more capital (and energy) intensive production in the furniture industry. While the national index of casegoods shipments for 1976 was approximately identical with that of 1974, upholstered goods shipments increased by 13 percent.¹¹

Since upholstered furniture manufacture is relatively capital intensive, it would seem that post-1974 energy-use increases should have appeared in Exhibit I. However, shifts toward upholstered product lines were paralleled by a rationalization process in furniture manufacture. This led to transfer of energy-

¹⁰ Some of this discrepancy may be due to our unfortunate failure to define capacity as, for example, "one shift capacity" in the questionnaire. However, the discrepancy is more a reflection of recession's impact.

¹¹ Source: National Association of Furniture Manufacturers array of Wharton EFA statistics. One of the plants included in our survey reported that its shipments of upholstered furniture had increased 60 percent between 1974 and 1976, while its casegoods shipments actually declined by 2 percent.

EXHIBIT VIII
 LABOR COST AS A MULTIPLE OF ENERGY COST:
 PER DOLLAR OF SHIPMENT VALUE, 1976

Number of Em- ployees Item				
	1-20	21-100	101-500	> 500
Wood Household and and Office Furniture (SIC Code 251)	13.64	12.50	25.00	25.00
Metalworking and Machinery Tools (SIC Code 354)	9.95	17.86	23.40	21.05

Source: Exhibit VII

intensive operations (for example, kiln drying; dimensional shaping) toward the producing forests, and also reduction in the amount of wood finishing performed by furniture plants. Since New England draws heavily on Canadian hardwood sources, this (one-time) reduction in the local demand for energy more than offset 1974-1977's growth in energy usage for upholstered furniture manufacture.

5. Manufacturers' substitution of cheaper for more expensive energy sources has led some firms to conclude they are conserving fuel quantitatively, when in fact they are merely controlling the rate at which their total energy costs are changing. This apparent anomaly became apparent when the project team developed BTU consumption statistics after being told by a machine tool builder that his plant's total energy costs had declined 8 percent in three years. Substitution of oil for electricity as a heating source had brought a substantial reduction in energy costs on the corporate income statement. At the same time, total BTU's consumed per dollar of shipment value had increased close to 11 percent.

The extent to which New England firms have changed the mix of energy sources used in manufacture cannot be precisely determined from our incomplete data base. The evidence we have compiled suggests that the number of plants using wood or solid waste as an energy source increased approximately three-fold over the 1974-1977 period (see Exhibit IX).

6. Efforts by public utilities to stimulate energy conservation through initiation of off-peak production have been ineffective to date, and appear likely to remain thus until labor market surpluses are exhausted. In responding to the survey questionnaire, executives of several large plants indicated that local electric power companies had offered them off-peak rate cuts of approximately 10 percent. Since such a rate reduction would have covered no more than 2-5 percent of projected increases in hourly labor costs (due to additions to the hourly wage base), consideration of off-peak production was suspended.

Other executives strongly criticized the use of electricity demand charges, claiming that they tend to have an energy-extensive, rather than conserving, impact. (Exhibit X presents data on the percentage distribution of plants subject to supplemental electricity changes.)

7. There is little concern in New England regarding the adequacy of the energy supplies which will be available in future years. Concern regarding future energy sources was mentioned in only three of the site-visited plants. Two of these plants were operated by national corporations which had diverted production to New England during last winter's Southern and Mid-Western natural gas shortage. Our interviewees contrasted New England's supply prospects favorably with the conditions facing manufacturers elsewhere in the United States over the medium term.

EXHIBIT D
PRIMARY FUEL AND ENERGY SOURCES, 1976
A. Wood Household and Office Furniture (SIC 251)

Tier and Number of Employees	Northern Tier					Southern Tier				
	1-20	21-100	101-500	501-1,000	> 1,000	1-20	21-100	101-500	501-1,000	> 1,000
1. For Building Heat, Light										
Oil: #2 (5.880m Btu/bbl)	100%	42%	20%				50%	20%	20%	
#4 (6.216m Btu/bbl)		41	20				50	20		
#5 (6.384m Btu/bbl)			20						50	
#6 (6.384m Btu/bbl)			40					40		
Gas: (1,021 Btu/ft. ³)						25		20	50	
Electricity (3,412 Btu/Kwh)			20							
Wood Waste		17	40					20	40	
Total*	100%	100%	160%			100%	100%	120%	160%	
3. For Motive Power and/or Process Heat										
Electricity	100%	100%	100%			100%	100%	100%	100%	
Gas		17	20			25				
Total*	100%	117%	120%			125%	100%	100%		100%

B. Metalworking Machinery and Equipment (SIC Code 354)										
Tier and Number of Employees	Northern Tier					Southern Tier				
	1-20	21-100	101-500	501-1,000	> 1,000	1-20	21-100	101-500	501-1,000	> 1,000
1. For Building Heat, Light										
Oil: #2	50%	33%	60%	50%		50%	33%	30%	50%	
#4		33						30	50	
#5		34		50						100%
#6		15					34	40		
Gas			40			50	33			
Electricity	50					50				
Solid Waste										20
Total*	100%	115%	100%	100%		150%	100%	100%	100%	120%
2. For Motive Power and/or Process Heat										
Electricity (Purchased)	100%	100%	100%	100%		100%	100%	100%	100%	
Electricity (generated by own steam turbine)										80
Gas		15	60	50			33	80	50	
Total*	100%	115%	160%	150%		100%	133%	180%	150%	180%

*Total > 100% when more than one energy source used per respondent.
Source: Survey questionnaires.

EXHIBIT X
 PERCENTAGE DISTRIBUTION OF COMPANIES SUBJECT
 TO SUPPLEMENTAL ELECTRICITY CHARGE:
 BY TIER

	Northern Tier	Southern Tier
1. Demand Charge	15%	10%
2. Peak Load Pricing	15	6
3. Demand Charge or Peak Load Pricing	23	31
4. No Supplemental Charge	23	18
5. Don't Know	<u>23</u>	<u>35</u>
Total	100%	100%

Source: Survey questionnaires

The comptroller of the third plant suggested that New England manufacturers have less reason to fear any future shortage than do producers in other parts of the United States. He based his judgment on New England's underutilized hydroelectric potential.

8. Increases in energy costs are accepted with relative equanimity, since the practice of "passing through" increased supply or utilities costs became institutionalized during the 1971-1974 years of national price controls.

III. OPPORTUNITIES FOR INCREASED CONSERVATION OF ENERGY: 1977-1985

A. Investment to Rehabilitate Plant

The foregoing considerations suggest that there will be a tendency to increase energy intensity in the manufacture of wood furniture and metal working equipment over the years 1977-1985. One means of reducing this tendency may lie in amended regulation of utilities rates. Assessment of demand charges and use of peak load pricing might appropriately be reviewed, with the object of determining a pricing pattern which is equitable to both producers and consumers, and which also tends to promote energy conservation.

More comprehensive opportunities for conservation center in investments designed to conserve the amount of energy used for heat, light and environmental services. Exhibit XI characterizes plant condition by size of firm. The resulting profile--which appears to hold true to both the Northern and Southern Tiers--suggests that 60 percent of the plants used for furniture manufacture, and 94 percent of the region's metal working plants, require capital investment for energy conservation.¹³

Of a total of 1635 plants, 543 are classified as "obsolete" and require major structural modification. The actions of firms occupying such premises suggest that it would prove marginally economic at best, to invest in energy conservation projects within these plants. This leaves a population of about 240 furniture, and 650 metal working, plants--respectively 51 and 56 percent of the two industries--with obsolescent characteristics which make them suitable for energy-saving capital investment.

Need for investment thus remains, despite Exhibit XVII's record of projects recently undertaken to promote energy conservation. Other statistics show the percentage of establishments which are economically suitable for investment (Exhibit XI), and the reasons given for a failure to invest (Exhibit XII).

Failure to invest may be due either to the cost of capital, or to lack of any perceived advantage in so doing. Capital costs are likely to be particular impediments where short-term resale of new equipment cannot occur in the event of business downturn. Since this form of "downside risk" applies particularly to semi-permanent installations, we infer that fifty-five percent of those manufacturers who operate in obsolescent plants are reluctant to invest in energy conservation projects, due to capital costs. Numerically, these percentages translate as follows:

¹³ These figures are for establishments housing fewer than 501 employees: that is, for 100 percent of SIC 251/2, and approximately 90 percent of SIC 354.

EXHIBIT XI
PROPORTION OF MANUFACTURING PLANTS SUITABLE FOR ENERGY-CONSERVING INVESTMENT, 1977

A. Wood Household and Office Furniture (SIC Code 251)

Number of Employees					
Plant Classification*		1-20	21-100	101-500	> 500
		40%	10%	5%	
		40	75	30	Not
		20	15	65	Available
		100%	100%	100%	

B. Metal Working Machinery and Equipment (SIC Code 354)

Number of Employees					
Plant Classification*		1-20	21-100	101-500	> 500
		40%	30%	15%	
		55	60	50	Not
		5	10	35	Available
		100%	100%	100%	

Plant Classification*

Obsolete: Requires fundamental structural modification, such as: (1) replacement of all windows, (2) complete insulation, (3) new heating system and ductwork.

Obsolescent: Requires capital investment, such as: (1) new furnace/boiler, (2) heat pump or recycling equipment, (3) power-use control system.

Modern: Requires changes which can be handled as charges to current account.

Source: Survey questionnaires.

EXHIBIT XII
PERCENTAGE OF PLANTS CARRYING OUT, OR REJECTING, CONSERVATION PROJECTS THROUGH AUGUST 1977

Tier and Number of Employees		New England				Northern Tier				Southern Tier			
		1-20	21-100	101-500	> 500	1-20	21-100	101-500	> 500	1-20	21-100	101-500	> 500
<u>Wood Household and Office Furniture (SIC 251)</u>													
1.	Major Project (=Capital investment to replace obsolescent facilities)	Neg.	20%	42%	(Insufficient Sample)	Neg.	5%	25%	(Insufficient Sample)	25%	55%	(Insufficient Sample)	
2	Minor Project (=Current account expenditure to update modern facilities)	81%	80	97		100%	80	100		75%	80	95	
3.	Reasons for Noninvestment*												
	Cost of Capital	20	34	68		100	66	80			25	55	
	No Perceived Advantage		32								40	10	
	Excessive Property Deterioration		23	25			33	20			20	30	
	Energy-Efficient Plant		Neg.	25				20			10	30	
	Other**	20	Neg.	Neg.						25	Neg.	Neg.	
4.	Adjustment of Shifts to Conserve Energy	Neg.											
<u>Metalworking Machinery and Equipment (SIC 354)</u>													
1.	Major Project (=Capital investment to replace obsolescent facilities)	Neg.	Neg.	30%	68%	Neg.	5%	Neg.	50%	Neg.	85%	95%	
2.	Minor Project (=Current account expenditure to update modern facilities)	100%	85%	30	75	100%	85	Neg.	Neg.	100%	85	100	
3.	Reasons for Noninvestment*												
	Cost of Capital	43	16			100	40			50	10	15	
	No Perceived Advantage	50	60	30	65	Neg.	Neg.		Neg.	95	85	33	87
	Excessive Property Deterioration		10	10	88		30		Neg.	Neg.	Neg.	12	86
	Energy-Efficient Plant		15	15	8		15		Neg.	16	18	77	
	Other**		Neg.	30	15		15		Neg.	Neg.	Neg.	35	44
4.	Adjustment of Shifts to Conserve Energy	Neg.								10			

*Total > 100% when more than one reason listed.

**For example, "Energy cost/availability not a significant concern"; "Don't Know"; "Building to be sold"; "Conservation Projects being examined".
Neg. = Negligible (less than 5%).

Source: Survey questionnaires.

	<u>Plants Suitable for Investment</u>	<u>Investment Not Made Due to Capital Costs</u>
SIC 251/2	240	110
SIC 354	650	380

B. Investment in Energy-Conserving
Manufacturing Processes

Machinery and tools represent forms of capital investment which carry reduced downside risk. In times of business adversity, at least partial recovery of out-of-pocket costs should be available through resale of recently acquired machines. Consequently, investment financing is relatively easy to obtain; often it can be acquired at quite advantageous interest rates. Despite these facts, we infer that lack of perceived advantage inhibits investment in energy-conserving tools by 40 percent of New England's furniture makers and metal working equipment manufacturers. Numerically, the estimated distributions are as follows:

	<u>Plants Suitable for Investment</u>	<u>Investment Not Made Due to Lack of Perceived Advantage</u>
SIC 251/2	240	50
SIC 354	650	600

Exhibit IX (page 17) showed that purchased electricity is used as the predominant source of motive power by virtually all New England firms manufacturing wood furniture or metal working equipment. Considerable variation exists in the energy required for production by firms of different sizes (Exhibits XIII and XIV). Generally, however, air compressors, process heat units, and environmental services equipment carry the largest demands for power. As is shown in Appendix VI, energy-conserving systems are available for these applications. A conservative estimate is that installations in these areas will reduce the related portion of energy demanded by at least 20 percent.

Replacement of wood and metal working tools often carries promise of energy conservation, as well. For a premium of 15-20 percent in purchase price, energy savings of 10 to 15 percent can be attained per machine. However, survey responses indicate that managers in both the furniture and metal working industries are conservative in their machine tool replacement practices. The oldest metal cutting machines listed by survey respondents were purchased in the 1930's. One furniture manufacturer employing 90 people uses a number of tools which were purchased a decade earlier. On average, however, the two industries' oldest machines date from the end of the Korean War, while their newest tools are eight years old.

EXHIBIT XIII
HORSEPOWER RANGES FOR SPECIMEN MANUFACTURING,
HEAT GENERATING AND CONSERVING EQUIPMENT:
WOOD HOUSEHOLD AND OFFICE FURNITURE (SIC 251/2)


Type of Equipment	Number of Employees	1-20	21-100	101-500
1. Woodworking Equipment <div style="margin-left: 20px;"> Lathe Molder Planer Router Sander Saw Shaper Spray Booth Tenoner </div>		1 H. P. - 7.5 H. P.	1 H. P. - 10 H. P.	5 H. P. - 30 H. P.
2. Upholstery Equipment <div style="margin-left: 20px;"> Cutting tool Heat sealing machine Punch press Quilting machine Rivetting tool Sewing machine Shear machine </div>		No consistent patterns. Variation between 1 H. P. and 40 H. P. reported.		
3. Heat Generating and Conserving Equipment, and Other*				
Air compressors (powered by purchased electricity)		N/A	20 H. P. - 50 H. P.	50 H. P. - 180 H. P.
Blowers and dust collection systems		5 H. P. - 20 H. P.	60 H. P. - 350 H. P.	N/A
Heat pumps and other recycling systems		5 H. P. - 20 H. P.	60 H. P. - 350 H. P.	N/A
Water heaters		Most frequently gas or oil		
Wood hogs			75 H. P.	

*Many involve use of several motors, in series or independently sited in plant

N/A: Not available, or not applicable.

Source: Survey questionnaires.

EXHIBIT XIV
HORSEPOWER RANGES FOR SPECIMEN MANUFACTURING,
HEAT GENERATING AND CONSERVING EQUIPMENT:
METALWORKING MACHINERY AND EQUIPMENT (SIC 354)

Number of Employees		1-20	21-100	101-500	500
Type of Equipment					
1.	<div style="text-align: center;">  </div> Boring Broaching Drilling Grinder Lathe Machining centers Milling Planer	1 H. P. -10 H. P.	5 H. P. -50 H. P.	5 H. P. -100 H. P.	50 H. P. -100 H. P.
2.	Metal Treading Equipment Braising and Welding Quenching Pot Tempering Furnace	N/A	30 H. P.	50 H. P.	N/A
3.	Heat Generating and Conserving Equipment, and Other* Air compressors (powered by purchased electricity) Heat pumps and other recycling systems Water heaters	N/A	20 H. P. -70 H. P.	50 H. P. -300 H. P.	N/A

*May involve use of several motors, in series or independently cited in plant.
 N/A: Not available or not applicable.

Source: Survey questionnaires.

Survey respondents note that replacement of their newest machines would require payment of a premium averaging 33 percent--without the additional cost of energy-conserving adaptations. It is interesting to note that 88 percent of the respondents report that savings in labor costs could be attained through investment in new machines. On the other hand, only 10 percent of respondents foresee the possibility of improving energy efficiency through investment in new machine tools. No firm which responded to the survey questionnaire looks to re-tooling as a means for reducing materials waste--hence, to reduction in inefficient applications of energy. Possibly these attitudes are peculiar to the small number of firms which responded to the relevant topics on the questionnaire. They certainly do not parallel the material on energy conservation options which are contained in Appendix VI.

C. Decisions on Capital Budgeting

Our evidence suggests that many New England furniture and metal working equipment manufacturers are unaware of the opportunities for energy conservation which exist through capital investment. In general, it appears that sustained attention to the energy issue tends to be limited to those multi-plant corporations which are of sufficient size to charter permanent staff positions with responsibility for energy conservation activities.

Several factors bear on this conclusion. Our evidence suggests that, without an individual who carries assigned responsibility for conservation planning, the conduct of energy audits, and technico-financial analysis of energy conservation opportunities, the energy problem loses corporate visibility. Managerial action also will be limited unless the enterprise is sufficiently large and diverse so that flows of depreciated capital funds, possibly supplemented by external sources, are of a size permitting conservation investments in supplement to other beneficial investment projects.

The cash flow issue is particularly important. Limited investment funds always reduce the number of projects which can be carried out from among those candidates which carry an "acceptable" rate of return. The returns from energy-conserving projects are likely to be appreciably lower than the returns available from capital (and energy) intensive, labor-saving investments. Consequently, prudent management tends to reject energy-conserving investments unless (i) considerable liquidity exists in the firm; (ii) corporate policy explicitly requires energy conservation activities, and (iii) this policy has been carried to the point of assigning staff responsible for implementation of the conservation effort.

Among the plants site-visited, we found these conditions to obtain in three instances. Each plant was a member of a large, multi-establishment corporation. However, not all multi-plant manufacturers evidenced interest in energy-conserving investments. In one case, the probability of energy-related investment appears virtually nil in the near term. Current corporate policy requires payback on all capital budget projects within one calendar year.

Technically, this requirement effectively precludes any industrial investment in projects affecting heat, light and environmental services. Except in the case of relatively small machines, the policy also tends to prohibit payment of any premium charge in order to make new machine purchases both labor-saving and energy-conserving.

We have focused on the unusual above to add weight to the usual. Amongst New England furniture and metal working manufacturers, a two to three year payback requirement now appears to be standard. Without government assistance of some sort, the prospect for concerted activity to rehabilitate plant or introduce energy-conserving equipment appears small.

IV. PROBABLE, AND POSSIBLE, TRENDS IN THE DEMAND FOR ENERGY, 1977-1985

A. Introduction

Conservative investment policies are not unusual within New England wood furniture and metal working equipment manufacturing. They have been in existence much longer than the period covered by this report. Since energy conservation projects were carried out during 1974-1977, we can assume that comparable investment decisions will be made in future. This will occur despite price inelasticity in the demand for energy.

The backlog of potentially "acceptable" heat/light/environmental service projects has been reduced by an amount approximating the 1974-1977 investment. There being little reason to forecast extensive renovation of Obsolete plant, we project 1977-1985 investments in plant-related energy conservation at one minus the percentage of questionnaires evidencing an unwillingness to invest because of the cost of capital. After Obsolescent plants are upgraded to Modern status, we believe their energy efficiency will increase approximately 17 percent.¹⁴

The potential for heat/light/environmental service types of conservation is nonetheless limited by the overhang of Obsolete plants within New England. This is made evident by Exhibit XV. Even though small firms tend to apply the larger portion of their energy supplies to heat and light, their clustering in Obsolete factory space (combined with relatively small capital budgets) will force them to continue to make above-average allocations of energy to plant-related applications.

The prospect for energy conservation through machine tool investment is also constrained. We have chosen to apply the rule-of-thumb that machinery will be replaced at a rate of 5 percent per year. This may be an overly optimistic forecast. Several managers told members of the project team that they upgrade tools irregularly, and only when an advantageous deal can be made on second-hand equipment. This caveat notwithstanding, management's reluctance to pay premium prices for energy-efficiency will continue to limit the amount of conservation which can be attained through investment in new machine tools.

¹⁴This is derived from the reciprocal of the energy inefficiency coefficient (1.2 for Obsolescent plant) which is presented in Appendix I, Section B.1.

EXHIBIT XV
 PERCENTAGE DISTRIBUTION OF ENERGY APPLICATIONS
 AFTER "PROBABLY" INVESTMENTS: 1977-1985

<u>Industry & Employment Size</u>	<u>% to Heat, Light En- vironmental Services</u>	<u>% to Motive Power for Tools</u>
I. Wood Household and Office Furniture (SIC 251/2)		
1-20	72	28
21-100	42	58
> 100	46	54
II. Metal Working Machinery Equipment (SIC 354)		
1-20	60	40
21-100	53	47
> 100	41	59

Source: Survey Questionnaires

In projecting 1977-1985 investment in energy-conserving machine tools and equipment, we have used a coefficient equalling one minus the percentage of questionnaires indicating a failure to invest because of lack of advantage in so doing. We weight the average efficiency of energy applications to producing machinery as follows: an efficient, energy-conserving tool uses 11 percent less energy than an efficient, energy-extending tool, and 17 percent less energy than an inefficient tool.¹⁵

B. Optional Roles for Government in Stimulating Energy Conservation

Our conclusions regarding investment provide a "probable" boundary for projections of energy to be conserved during 1977-1985. What might be "possible", if the New England states undertook new initiatives to promote energy conservation in the manufacture of wood furniture and metal working equipment? Two types of initiative are listed in the contract scope-of-work.

1. Technical Assistance to Manufacturers. Section III.C noted that relatively few New England establishments have staff predominantly assigned to (i) the identification of opportunities for energy-conserving investment, (ii) the conduct of energy audits, and (iii) the performance of technico-financial analyses of the energy conservation potential contained in investment proposals. Manufacturing scale was found to be a key determinant of this condition.

Although the creation of an energy-conservation staff is likely to be limited to large corporations, necessary skills to perform the staffing function exist in all companies. Operationally, a key problem is that energy conservation planning and analysis may fall in the interstices between the mandates of corporate financial, and manufacturing authority.

A possible role for government would be to provide assistance in bridging the financial/manufacturing gap. This objective could be partially achieved by preparing and disseminating "systems" manuals on techniques for introducing technico-financial conservation analyses into the appraisal of investment proposals. Such an activity might well be supplemented by the design and distribution of materials--and the provision of other forms of technical assistance--in areas relating to the conduct of energy audits.

¹⁵ These figures are also derived from the reciprocal of coefficients presented in Appendix I, Section B.1. Underlying our initial choice of coefficients are the data of Appendix VI.

2. Financial Incentives for Energy Conservation. Technical assistance will have limited impact on investment behavior until such time as New England's wood furniture and metal working equipment manufacturers are convinced of the need for present conservation investments, in order to enhance future profit prospects. Exhortation will not serve this end. As we have seen, the cost of labor tends to militate in favor of labor saving, energy extending investments. Direct financial incentives may be required to ensure that technically "possible" levels of energy saving are finally achieved.

An investment tax credit is one instrument which might be used to provide financial incentives. If applied to the price premium charged for energy-efficient machinery and devices, the tax credit might influence managers to invest for energy efficiency in concert with productivity improvement.

A second incentive mechanism might be built on the provision of low interest, "energy-conserving" loans. This would appear particularly appropriate for application to plant rehabilitation investments. Alternatively, governmental guaranty of firms' medium-and long-term obligations to the financial sector might be initiated. If the social benefits are deemed sufficiently high, either direct loans or loan guaranties might be used to stimulate investment in the rehabilitation of Obsolete plants.¹⁶

Assessing the cost-effectiveness of any of the foregoing options would be difficult. At issue are not only the direct benefits and costs associated with the provision of resources to stimulate energy conserving investment. A number of indirect factors intrude as well. These necessitate evaluation of technical assistance and/or financial incentives against alternative options such as regulation of the volume of supply (directly, or through the price mechanism), or capital investment to increase supply (for example, through revitalization of the region's hydroelectric potential). A thread linking all alternatives is the question: how much energy conservation is technically possible?

C. "Probable" and "Possible" Levels of Energy Conservation in the Wood Furniture and Metal Working Equipment Industries: 1977-1985

Our projection of "possible" energy conservation has been narrowly constrained. We forecast no further upgrading of Obsolete plants for energy conservation. We foresee no increase in the annual, average rate of replacement

¹⁶ Since management behavior in New England indicates that capital investment to upgrade Obsolete plant would not be as beneficial as plant abandonment, we do not consider this option in this report. However, numerous local development commissions have pointed out that community benefit often can be gained by rehabilitating 19th Century factories.

for machine tools. Given these assumptions, data acquired through the field survey indicate that governmental intervention might decrease energy use by an amount approaching 1.25 percent per year (see Exhibit XVI). If this figure is multiplied by our data on 1976/7 energy consumption in New England's wood furniture and metal working equipment industries, governmental intervention would appear likely to cause a saving of approximately 600,000 barrels of Number 6 Oil or its equivalent, between now and 1985. Obviously, the potential for energy saving becomes more dramatic when one recognizes that any governmental programs for energy conservation would become available to all New England industries.

1. The Impact of Governmental Initiatives on the Price Elasticity of Demand for Electricity and Fuels. Materials presented in Section II indicate that price changes within the ranges experienced between 1974 and 1977--or projected in this study as a real-term price line through 1985--are insufficiently great to induce much energy-conserving investment. Investment commitments will tend to be made to satisfy cost-reducing objectives in the labor and materials areas, rather than to offset increases in energy price. This being the case, problems caused by the lack of adequate responses to our field survey have been substantially overcome. Substitute analytic techniques (Appendix I) have provided a basis for computing and projecting elasticities.¹⁷ The results of this exercise are given numerically in Exhibit XVI and graphically on Exhibits XVII and XVIII.¹⁸ These exhibits reinforce a point made earlier in Section IV.B: governmental interventions of the types discussed in this report appear likely to have relatively small impact on the elasticity of demand for electricity and fuels. This is an unfortunate conclusion, since the thrust toward energy conservation which was achieved during 1974-1977 appears to have been largely a product of actions, such as the lowering of thermostats, which cannot be replicated indefinitely.

¹⁷ It may be appropriate, however, to question the use of the elasticity concept to forecast demand at all, since factors other than energy price appear to drive the investment decision within the price ranges used for this study.

¹⁸ Again, we note that the structural and extrapolative techniques used in this report tend to overstate E_D measurements in early years, and to understate them later on. This largely accounts for the positive elasticities recorded for SIC 251/2 in 1985 (Exhibit XXI). Because of this condition, use of an average E_D , or of E_D measured between terminal years, appears to be desirable.

EXHIBIT XVI
PROJECTED ELASTICITIES OF DEMAND FOR ENERGY:
ALL NEW ENGLAND FIRMS IN INDUSTRIES SIC 251/2 AND 354

Without Governmental Intervention				With Governmental Intervention			
	Btu's/\$ of Product Shipments*	Energy Price Line	E_D		Btu's/\$ of Product Shipments*	Energy Price Line	E_D
Wood Household and Office Furniture (SIC 251/2)							
1977	208.7	100.00		208.7	100.00		
1978	203.8	101.50	-1.5652	203.5	101.50	-1.6611	
1979	199.9	103.02	-1.2779	197.8	103.02	-1.8704	
1980	199.0	104.57	-0.2992	197.0	104.57	-0.2688	
1981	198.4	106.14	-0.2008	196.3	106.14	-0.2322	
1982	198.1	107.73	-0.1009	195.7	107.73	-0.2080	
1983	197.8	109.34	-0.1013	195.4	109.34	-0.1026	
1984	197.7	110.98	-0.0337	195.1	110.98	-0.1024	
1985	198.8	112.65	+0.3643	195.7	112.65	+0.2044	
	E_D (Terminal Years) = -0.3750				E_D (Terminal Years) = -0.4924		
Metal Working Machinery and Equipment (SIC 354)							
1977	116.96	100.00		116.96	100.00		
1978	112.83	101.50	-2.3541	112.51	101.50	-2.5365	
1979	111.30	103.02	-0.9055	110.53	103.02	-1.1752	
1980	110.76	104.57	-0.3225	110.05	104.57	-0.2886	
1981	110.34	106.14	-0.2526	109.85	106.14	-0.1188	
1982	110.32	107.73	-0.0121	109.37	107.73	-0.2974	
1983	110.22	109.34	-0.0607	109.38	109.34	-0.0061	
1984	109.86	110.98	-0.2190	109.16	110.98	-0.1341	
1985	109.71	112.65	-0.0907	108.79	112.65	-0.2253	
	E_D (Terminal Years) = -0.4900				E_D (Terminal Years) = -0.5522		

*Btu's/\$ of Product Shipments is a weighted aggregate for each industry. The weights used to reflect percentage of firms in each of several employment size classifications are:

	<u>1-20</u>	<u>21-100</u>	<u>>100</u>
SIC 251/2	.5798	.3235	.0966
SIC 354	.6367	.2758	.0875

Since the Btu's projections are normalized, the values presented are not cross-comparable between SIC 251/2 and SIC 354. Elasticities, however, are.

EXHIBIT XVII
THE IMPACT OF POSSIBLE GOVERNMENTAL INTERVENTIONS
ON THE ELASTICITY OF DEMAND FOR ENERGY: 1977-1985

[Wood Household and Office Furniture (SIC 251/2)]

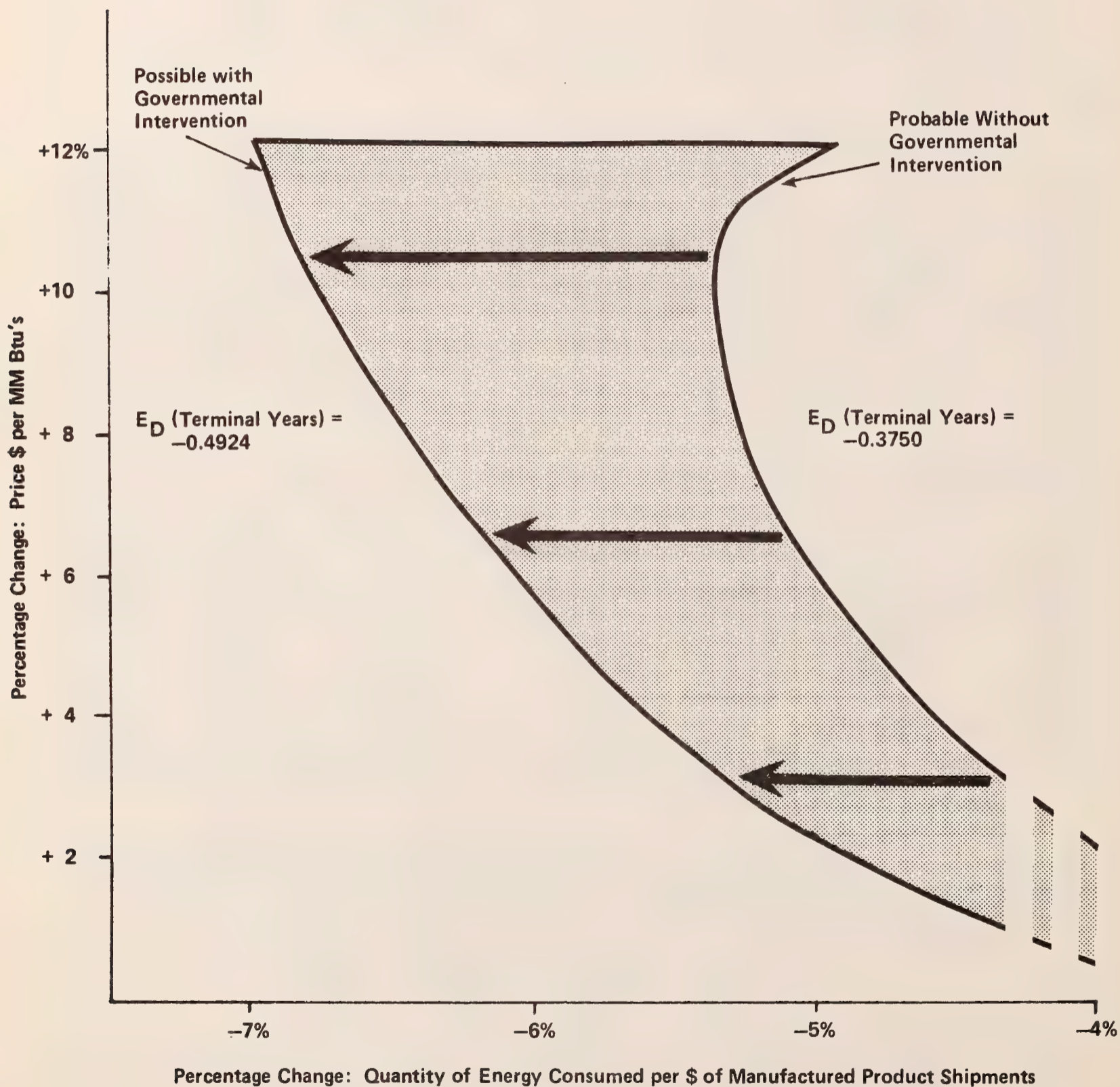
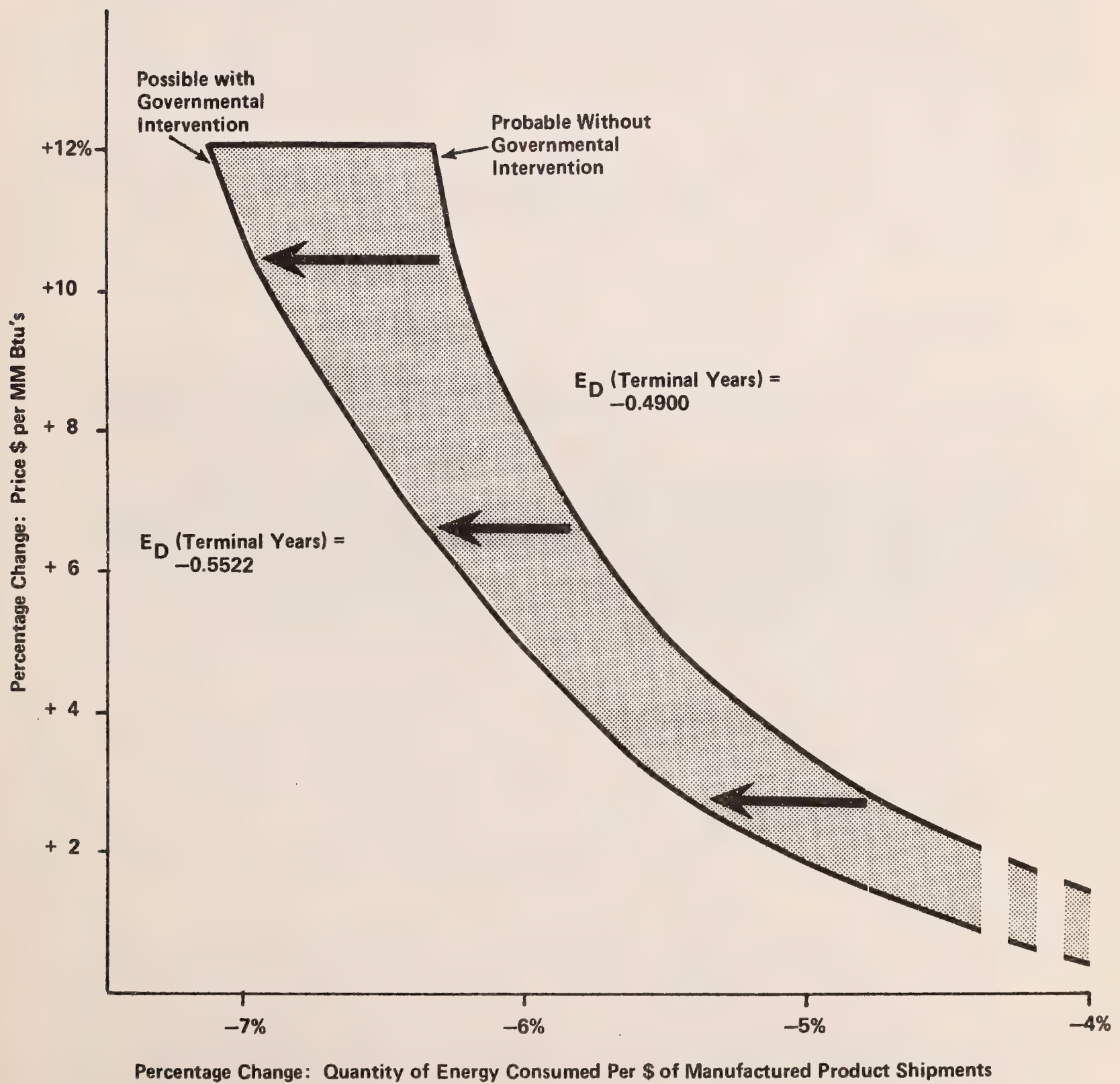


EXHIBIT XVIII
THE IMPACT OF POSSIBLE GOVERNMENTAL INTERVENTIONS
ON THE ELASTICITY OF DEMAND FOR ENERGY: 1977-1985

[Metal Working Machinery and Equipment (SIC 354)]



D. The Impact of Energy Price Rises on
New England's Industrial Competitiveness

We noted above (Section II, Point 7) that managers interviewed in plant visits expressed little concern regarding the impact of rising energy costs on New England's competitive position. On the contrary, because New England's electricity and fuel supplies are looked on as being more secure than are those of other regions, the energy problem is thought likely to rebound to the advantage of Northern and Southern Tier manufacturers. This does not mean that relocation out of New England is no longer being considered within the two industries. The drive toward rationalization of manufacturing processes still continues. But it does mean that, since price rises within forecasted ranges are not felt to be excessive, projected increases in the price of energy are viewed as being unlikely--in and of themselves--to affect market shares, or the number of wood furniture and metal working manufacturers located in New England.

E. Conclusions

Three fundamental conclusions can be drawn from the materials presented above. First, projected increases in the price of energy are not likely to occasion dramatic new efforts at energy conservation by firms within the two subject industries of this report. Second, New England manufacturing may benefit, rather than suffer, from the energy problem: our supplies are (relatively) secure. Finally, governmental assistance can marginally assist in stimulating further energy conservation by industry. But it remains moot whether introduction of the types of assistance described above would be highly cost-effective.

APPENDIX I ANALYTIC PROCEDURES

A. Computation of 1977/1974 Elasticity Measures (Exhibit I)

The elasticity concept is designed to permit comparison of the proportional changes of two variables. Formally, the price elasticity of demand (E_D) is defined as

$$E_D = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}}$$

$$= \frac{Q_t - Q_{t-1}}{P_t - P_{t-1}} \times \frac{P_{t-1}}{Q_{t-1}}$$

where t = time at some stated moment, and $t-1$ = time at some stated moment preceding t .

Since the amount of energy consumed in manufacturing operations is in part determined by the level of production achieved, we must consider not only how changes in the price of energy directly affect the quantity demand for energy but also, proportionately, how changes in the price of energy relate to the consumption of energy per dollar of production output. Association of energy usage with production levels is particularly important in the current analysis, for information gathered in field research indicates that attempts will probably be made to increase the energy-intensity (and labor-conservation) of manufacturing processes in future until (unknown) levels of capacity utilization are reached. (This condition means that the use of constant technological production functions below must be held in question.) Further, we learned in the field that the practice of "passing through" incremental energy costs will remain in being during the foreseeable future.

With these points in mind, we have defined "the value of energy consumed per dollar of manufactured product shipments" as a measure approximating the variable Q . This practice does not permit identification of the technological changes in production function which occurred during 1974-1977, nor the changes in product mix which took place over the same period. But our Q approximation is the most accurate measure available to us, given the data at hand.

Use of the "per dollar of shipments" surrogate for Q results in the following mensuration process for determining SIC 251/2's average 1974-1977 E_D .

	<u>1974</u>	<u>1977</u>
1. <u>Energy Consumption and Cost</u> ¹		
a. Electricity		
BTU (= KWH x 3,412)	(3.1776) ⁹	(3.4238) ⁹
\$ Cost	38,593	47,655
b. #2 Oil		
BTU (= Gals x 140,000)	(4.3400) ⁹	(7.9816) ⁹
\$ Cost	9,236	20,145
c. #4 Oil		
BTU (= Gals x 148,000)	(15.207) ⁹	(14.193) ⁹
\$ Cost	12,741	23,016
d. Total BTU	(22.72) ⁹	(25.60) ⁹
e. Total Energy \$ Cost	60,570	90,816
f. Price/BTU	(2.6659) ⁻⁰⁵	(3.5475) ⁻⁰⁵
2. <u>\$ Value of Shipments</u>	(4,303) ³	(5,510) ³

In consequence:

Value of Energy Consumed Per \$ of Manufactured Product Shipments [Q]:

$$1974: \frac{(22.72)^9}{(4,303)^3} = 5280.037$$

$$1977: \frac{(25.60)^9}{(5,510)^3} = 4646.098$$

¹Numbers in parentheses follow scientific notation. The exponent indicates that mantissa should be multiplied by 10^x .

Price \$ Per MM BTU's [P]:

1974: \$266.59

1977: \$354.75

$$E_D = \frac{4646.098 - 5280.037}{354.75 - 266.59} \times \frac{266.59}{5280.037}$$

$$= -.36307 \text{ (see Exhibit I).}$$

A similar procedure is employed in developing the SIC 354 elasticity of demand. However, a modification has had to be introduced so that the final composite E_D will accurately reflect the percentage distribution of metalworking plants numbering 101-500, 501-1,000, and greater than 1,000 employees (respectively, 64, 20, and 21). For this purpose, total figures on energy consumption and cost, and on shipments value are weighted by the proportionate size distributions of the relevant employee classifications. This process ultimately yields the SIC 354 elasticity measure: $E_D = -.09077$ (see Exhibit I).

B. Projection of Elasticity Measures (E_D): 1977-1985

Lacking reliable data on managerial decision processes, the rates of return on investment (ROI) which will tend to induce build-up of the energy-conserving capital base, and on 1974-1977 derived demands for energy in several of our industry classifications, we are not able to build projections of the elasticity of demand for energy (E_D) by conventional methods. The following section arrays the algebraic equations which were employed as a substitute.

The substitute technique assumes constant production functions and propensities of investment. Consequently, it tends to overstate the E_D change rate in the period 1977-1980, while understating E_D in the periods thereafter.

The central concepts underlying the model are that (i) total manufactured product shipments will remain stable during 1977-1985;¹ (ii) energy (expressed in BTU's) totals 100 percent in 1977; and (iii) the percentage distribution of energy usage amongst plant and equipment types will change according to constant functions measuring the propensity to invest. Given these concepts and a predetermined price line equalling 1.5 percent growth per year, the task of E_D measurement centers on iterative solution of Q for each of the years, 1977 through 1985, as follows.

¹This is a simplification introduced for computational purposes alone. Since Q continues to measure energy consumed per dollar of manufactured product shipments, the E_D results are essentially unaffected.

1. Distribution of BTU Usage by Plant and Equipment of Differing Characteristics (1977)

$$Q = \sum_{i=1}^n e_n Q_n \quad (1)$$

where Q = Total BTU's consumed within industry, per \$ of manufactured product shipments

Q_n = Total BTU's consumed by plants of the nth employment size, ...

e_n = Percentage of industry within the nth employment size category

$$Q_n = R_n + M_n \quad (2)$$

where R_n = BTU's consumed by plants of size n for heat/light/environmental services

M_n = BTU's consumed by plants of size n for motive power

$$R_n = \sum_{i=1}^m g_m^j \quad (3)$$

where g_m = Percent of plants R_n at the mth level of energy inefficiency

j = Coefficient of energy inefficiency of plant types (Modern = 1, Obsolescent = 1.2, Obsolete = 1.3)

$$M_n = \sum_{i=1}^p h_p^k \quad (4)$$

where h_p = Percent of plants R_n at the pth level of motive power inefficiency

k = Coefficient of energy inefficiency of motive power sources (Efficient: Energy Conserving = 1, Efficient: Energy Extending = 1.12, Inefficient = 1.2).

2. Computational Requirement (1978-1985)

Given the foregoing distribution of Q in 1977, the initial requirement is to determine how BTU consumption will change over time, assuming:

(i) For plant heat /light/environmental services:

- Obsolete plants will receive no investment.
- Obsolescent plants will be upgraded to Modern status at a rate equal to one minus the percentage of questionnaire respondents who indicated an unwillingness to invest because of the cost of capital.
- New, energy-conserving investments will come on-stream following a lag of 1.5 years from the initial commitment to invest.

(ii) For motive power:

- All production machinery will be replaced at a rate of 5 percent per year.
- Replaced Inefficient, and Efficient: Energy-Extending machinery will be made Efficient: Energy-Conserving at a rate equal to one minus the percentage of questionnaire respondents who indicated an unwillingness to invest due to lack of perceived advantage therein.
- New machinery will come on-stream following a lag of 0.5 years from the initial commitment to invest.

3. Adjustment for Possible Government Interventions into the Investment Process

This requirement is satisfied by repeating the steps outlined above, after the following changes have been made to investment propensity functions:

- Government investment incentives increase to .9, the propensity to invest in upgrading Obsolescent plant.
- Government investment incentives increase to 1.0, the propensity to upgrade machinery to Efficient: Energy-Conserving status.
(Replacements continue to be made at a rate of 5 percent per year.)

C. Projected Elasticity of Demand for Energy
by New England Firms (see Exhibit II)

This exhibit employs the model's characteristics to demonstrate how the consumption of energy is likely to change over the next eight years, assuming that no governmental investment incentives are offered.

The exhibit demonstrates our method's tendency to overstate changes in E_D during the early years, while understating E_D towards the end of the period. If the E_D measurements are based on the terminal years alone, SIC 251/2's $E_D = -0.3974$ (yearly average = -0.0497) and SIC 354's $E_D = -0.1609$ (yearly average = -0.0201). Since both measures (i) reflect optimistic assumptions regarding the propensity to invest in energy-conserving devices; (ii) are in some (uncertain) degree biased by the effects of relatively large, temporary reductions of energy usage for heat and light during 1974-1975; and (iii) make no adjustment for either the impact of the business cycle, or growing managerial confidence regarding the medium-term adequacy of New England energy sources, we believe that Exhibit II's relatively inelastic projections of energy usage, may, in fact, prove excessively elastic.

D. Projected Elasticity of Demand, With or Without
Governmental Intervention (see Exhibit XVII and XVIII)

These exhibits also employ the model equations. Instead of quantitative data on 1977 supply usage (as in Exhibits I and II), 1977's aggregate Q is valued at 100. Q is figured by proportionately weighting the distribution of firms in different size categories, according to the questionnaire-based percentage distributions of plants in the Obsolete, Obsolescent and Modern; and in the Efficient: Energy-Conserving, Efficient: Energy-Extending, and Inefficient, categories.

APPENDIX II

CONTRACTED SCOPE OF WORK (EXTRACT)

The Contractor's services will be employed to estimate the economic impacts on selected New England Industries of changes in energy prices, changes in energy price structures (e.g. electricity rate structure), and governmental energy conservation programs. The overall goal is to determine the ability of industry to react to, or take advantage of, energy-related changes in the business environment.

A major product of the "impacts" research is to be the formulation of long-term, implicit energy-demand elasticities which can be used in econometric modelling. The industrial groups to be studied are the following:

1. Metalworking machinery (SIC codes 3540-3549)
2. Furniture, woodworking (SIC codes 2510-2521)

The time frame for the study is an eleven year period through 1985. The reference period will be 1974.

The detailed tasks identified below are to address three issues of general relevance:

- A. The energy price or pricing structure at which representative industries will find capital investment for improved energy efficiency to be economically feasible;
- B. The prospective impact--on corporate decisions for investment or disinvestment in New England--of changes in New England energy price levels relative to those of other geographic regions; and
- C. The effectiveness of policy options which are available to government, and which may be used to stimulate improved usage of energy by New England industrial firms.

APPENDIX III
REPRESENTATIVE TOPICS FOR DISCUSSION IN
ENERGY POLICY MEETING

1. Type, amount, cost of fuel/electricity/purchased steam consumed:
1974-1977
2. Plant production (# units, lbs., \$ value): 1974-1977
Projections toward 1985
3. Energy conservation experience since 1974
Adjustment of shifts?
4. Heat, light, power-generation equipment audit
Age, capacity, original and replacement cost
5. Percentage distribution of manufacturing costs: 1974-1977
Projections toward 1985
6. Operating or investment options for improving energy efficiency
Cost factors associated therewith
7. Capital investment decision-making
ROI, ROA or other measures used to evaluate capital budget
projects
Non-financial tradeoffs bearing on decision
8. Lag-times between investment commitment and on-stream operation
9. Price sensitivity of major product lines
10. Comparative advantage/disadvantage of New England plant location
11. Marketing factor in relocation decisions

APPENDIX IV
TELEPHONE SURVEY OF ENERGY USE

Introductory Background Statement

Harbridge House is conducting a survey on energy use by New England manufacturers of household and office furniture, and of metalworking machinery and equipment. The survey will cover all New England states, though it is being directed by Massachusetts Energy Policy Office for FEA.

Combined with plant visits and secondary data analysis, the phone survey will help us determine:

1. How firms may adjust to any increases in the cost of energy down through 1985;
2. Whether low interest loans, investment tax credits, or some other form of governmental support may be needed to help New England manufacturers stay competitive in the future.

I'd like to ask you some questions about ways [company name] has responded to rising costs of fuel. My questions will take about 5 minutes to answer. Your answers will then be combined with those of others in the survey, so that all materials will reflect averages rather than conditions in single firms. In short, we'll be speaking in complete confidence. OK?

SURVEY QUESTIONNAIRE

Company # _____ *

Data to Fill off Telephone

Company Name: _____ SIC # _____

Respondent: _____ Phone _____

Title: _____

Location (Town, State) _____ N.E. Corp. Y _____ N _____

No. of Employees: 1-20 _____ 21-100 _____ 101-500 _____ 501-1000 _____ over 1000 _____

* Assign company number used in questionnaire.

1. In 1974, did you have any free-standing, energy generating equipment such as a power plant, heat recycling equipment or gen. sets [i.e., generator sets]?

Yes [Specify] ?

a _____

b _____

c _____

d _____

No [Go to Option B, Page (5)]

OPTION A

2. Which of these units provide heat? _____ [use letters]

Did they also generate steam for manufacturing applications?

Yes _____ No _____

3. Which provide electricity for lighting? _____ [use letters]

4. Which provide power for machinery operation? _____ [use letters]
5. We're interested in the age, original cost, and power rating of your energy-and heat-generating equipment. Can you give me rough estimates?

<u>Approx. Year Purchased</u>	<u>Estimated Purchase Cost</u> *	<u>Power Rating</u>
a. _____	\$ _____	_____
b. _____	\$ _____	_____
c. _____	\$ _____	_____
d. _____	\$ _____	_____

* If rough "ball park," Note B. P.

6. If you were to replace this equipment today, roughly how much would it cost?

a. \$ _____	c. \$ _____
b. \$ _____	d. \$ _____

7. What kinds of fuel are used in this quipment?

a. _____	c. _____
b. _____	d. _____

8. Have you introduced any programs to economize on fuel use? When?
 _____ Can you describe the program or the modification
 of your power equipment? _____

By about what percent did it reduce your fuel purchases: a. _____%

b. _____%

c. _____%

d. _____%

9. Have you considered changing the fuels used for any of your energy generating equipment? (If yes, record):
- a. _____ Why? _____
- b. _____ Why? _____
- c. _____ Why? _____
- d. _____ Why? _____
10. Why haven't you made the change in fuels as yet?
- Environmental regulations: _____
- Capital costs: _____
- Other (Specify): _____

Closing to Option A

We have a few other questions which deal with energy use by four major types of machinery and equipment, with change in the cost of fuels since 1974, and--for background--with the general manufacturing volume of your business. Might I send a short questionnaire to you on these points? The questionnaire could be filled in by one of your administrative staff in a very short time.

Thank you very much. Incidentally, we'd be happy to see that you get a copy of the final report if you'd like.

Yes _____

I'll put the questionnaire in the mail today. We're sort of in a situation where we need all our information yesterday.

Option B

[from 1]

11. How about your tools and equipment which have attached power or heat-generating motors? Would you list for me your four classes of tool or processing equipment which consume the greatest test amount of electrical or other energy?

EquipmentNon-Electric Energy Source [see 12]

a. _____

b. _____

c. _____

d. _____

12. Are they all electric-powered? _____. [If no, list the type of power source used in the right hand column of #11.]

13. Have you introduced any programs to economize on energy use? When _____? Can you describe the program, or the modification of your manufacturing equipment? _____

14. By about what percent did it reduce your energy purchases?

_____ % (Electric)

_____ % (Energy Source _____)

_____ % (Energy Source _____)

15. From the point of view of energy costs, might there be an advantage in shifting any of your manufacturing equipment to some other form of power source?

If yes (Specify): _____

16. Why haven't you made such a change as yet?

Environmental regulations: _____

Capital costs: _____

Other (Specify): _____

17. What is the name of the utility which provides your energy? _____

18. Does this utility use a variable rate such as peak-load pricing, or demand changes?

Yes _____

No _____

Closing to Option B

We have a few other questions which deal with the distribution of energy use in your plant, with change in the cost of fuels since 1974, and-- for background--with the general manufacturing volume of your business. Might I send a short questionnaire to you on these points? The questionnaire could be filled in by one of your administrative staff in a very short time.

Thank you very much. Incidentally, we'd be very happy to see that you get a copy of the final report if you'd like.

Yes _____

I'll put the questionnaire in the mail today. We're sort of in a situation where we need all our information yesterday.

V-1

APPENDIX V

Company # _____

DATA SHEET

NEW ENGLAND ENERGY POLICY ALTERNATIVES

Prepared By

Harbridge House, Incorporated
11 Arlington Street
Boston, Massachusetts 02116

September 1977

1. PRODUCTION AND SALES DATA

Please answer the following questions.

1. Major product lines manufactured at this plant.

2. Performance and capacity information

1974	1976	(6 mos.) 1977	Projected 1977
------	------	------------------	-------------------

a. Value of shipments from this plant.

b. Number of units, or pounds, shipped from this plant.

Please specify:

Units or Pounds

c. Percentage utilization of capacity

2. ENERGY AND FUEL CONSUMPTION

(gas, oil, coal, etc.)

V-3

Please fill in the first row blanks on "fuel type" (gas, oil, coal, etc.). Then answer the related questions about fuel usage, cost, etc.

Type	a. Electricity	b.	c.	d.	e.
1. 1974 Data					
a. Amount purchased					
b. Units (gals, Kwh, etc.)					
c. Cost	\$	\$	\$	\$	\$
2. 1976 Data					
a. Amount purchased					
b. Units					
c. Cost	\$	\$	\$	\$	\$
3. 1977 Data (6 mos.)					
a. Amount purchased					
b. Units					
c. Cost	\$	\$	\$	\$	\$
4. Name of the public utility which provides your electricity. _____					
5. Does this utility charge by a variable rate such as peak-load pricing, or demand charges? _____					

Yes _____ No _____

3. TOOLS AND EQUIPMENT WITH ATTACHED POWER OR
HEAT-GENERATING MOTORS
(Machine Tools, Kiln, etc.)

Please list on the first row the 4 types of machine tool or processing equipment which consume the greatest amount of electrical or other energy. Then answer the related questions. Where appropriate, answer "Yes," "No" or "N/A" (not applicable).

	Type			
	a.	b.	c.	d.
1. Uses electric power?				
2. Other energy source (identify)				
3. Number of tools in this plant?				
4. Age of oldest tool?				
5. Rated horsepower of oldest tool?				
6. Output/hour of oldest tool?				
7. Cost of oldest tool?	\$	\$	\$	\$
8. Age of newest tool?				
9. Rated horsepower of newest tool?				
10. Output/hour of newest tool?				

3. (Cont'd)

	Type	a.	b.	c.	d.
11. Cost of newest tool?		\$	\$	\$	\$
12. Today's replacement cost for this tool?		\$	\$	\$	\$
13. If you were to replace your oldest tool, how much more could you produce per KWH?					
14. Would there be savings in materials costs?					
15. Would there be savings in labor costs?					
16. Would there be savings in energy costs?					

4. FREE-STANDING ENERGY/POWER GENERATING EQUIPMENT
(Power Plant, Generator Sets, Heat Recycling Machinery, etc.)

Please fill in "Type" (for example, "Gen. Set") on the first row. Then answer the related questions about the type's function, age, and fuel source. Where appropriate, answer by "Yes," "No" or "N/A" (not applicable).

Function, etc.	Type	a.	b.	c.	d.
1. Provides heat ?					
2. Provides steam for manufacturing ?					
3. Provides electricity for lights ?					
4. Provides electricity for power ?					
5. Approximate year purchased.					
6. Manufacturer or name-plate ?					
7. Approximate purchase cost ?		\$	\$	\$	\$
8. Power rating ?					
9. Estimated replacement cost ?		\$	\$	\$	\$

4. (Cont'd)

Function, etc.	Type	a.	b.	c.	d.
10. Kind(s) of fuel used?					
11. Do you employ a station- ary engineer?		Yes _____	No _____		

Thank you for completing the questionnaire. Please mail it in the stamped and addressed return envelope to:

New England Energy Policy Research Project
Harbridge House, Inc.
11 Arlington Street
Boston, Massachusetts 02116

APPENDIX VI
ENERGY CONSERVING APPLICATIONS

1. For Use in Wood Furniture Manufacture
2. For Use in Metalworking Equipment
Manufacture
3. Computerized Listing of Topical Articles
4. Bibliography

APPENDIX VI.1
FOR USE IN WOOD FURNITURE MANUFACTURE

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Recycling/Waste Control	Use wood waste as boiler fuel.	Boiler retrofitted to use wood chips with fossil fuel as back-up. Manufacturers claim up to 100% fuel savings depending upon heating needs and volume of waste wood.	<u>Furniture Design and Manufacture</u> , Jan. 1977, p. 32.	York Shipley Inc., York, PA. Gebr. Weiss Boiler Co., U.S. Distributor: Energy Control Engineering Corp., Charlotte, NC.
	Recycle warm air generated by dust collection system for space heating.	Most dust collection systems produce clean, warm exhaust air which can be recycled into plant as space heating.	<u>Furniture Design and Manufacture</u> , Sept. 1977, p. 128.	Aeropulse, Inc. American Air Filter Co.
	Recycle heat from lumber drying.	Using heat pump principle, latent heat used to dry lumber is recycled. Manufacturers claim up to 70% energy savings.		C.E.A.F., Torino, Italy. U.S. Distributor: Stiles Machinery, Grand Rapids, MI.
	Use compressor-generated heat	Heat recovering air compressor regenerates heat for use in plant; manufacturer claims approximately 40% reduction in fuel use for plant heating.	<u>Furniture Design and Manufacture</u> , July 1976.	Unitemp Dry Kilns, Inc. Ingersoll-Rand.
	Energy-saving reheater for water-cooled screw compressor	Retrofit device made by manufacturer for its own line of compressors, but adaptive to most water cooled compressors.		Quincy Compressor Div. Colt, IN.

APPENDIX VI.1 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Reduce initial fuel consumption	Dust collection system	Energy efficient dust collection system which also recirculates warm exhaust air; manufacturers claim it uses as much as 75% less energy than conventional systems.		Moldow Dust Control, Inc., Greensboro, NC. CEA Carter Day Co., Inc.
	Energy-efficient compressor	New product which manufacturer claims saves 25% of electricity over conventional throttled inlet screw compressors.	<u>Furniture Design and Manufacture</u> , Sept. 1977, p. 130.	Gardner-Denver Co.
	Energy-saving planer	Line of planers which manufacturer claims are energy efficient.		Newman Machine Co., Greensboro, NC. Amersaag, Inc., Monsey, NY.
	One-pass finish sanding machine	One-pass finish sanding machine saves sanding time and thus energy consumed in sanding process.		Metzgar Conveyor Co.
	Energy-efficient conveyor system	Conveyor system moves greater loads at 0.5 HP than conventional slider-bed conveyors can at 1.5 HP; manufacturer claims 65% reduction in HP requirements.	<u>Iron Age</u> , June 20, 1977.	
Alternatives	Kiln dry without gas or oil	Electric dehumidification system; manufacturer claims it is more energy-efficient than gas or oil.	<u>Louisville Trade Fair</u> , ad under Merkara Development, Inc.	Westair Systems, Toronto, Ontario, Canada

APPENDIX VI.1 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Alternatives (cont.)	Purchase kiln-dried and surfaced lumber	Dimensioning plant can dry and surface wood more efficiently (cost-wise and energy-wise) than most furniture manufacturers can in-house.	<u>Furniture Design and Manufacture</u> , July 1977, p. 40.	

APPENDIX VI.2 FOR USE IN METAL WORKING EQUIPMENT MANUFACTURE

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Recycling/Waste Control	Reduce waste of lubricating oils	Waste from leakage and carry-off can be reduced up to 20% by replacing packings more often and using additives to swell seals and thus reduce leakage. Using chip-wringers reduces carry-off; keeping hoses tight reduces contamination.	<u>American Machinist</u> , Feb. 4, 1977, p. 50.	
	Recycle lubricating oils	All types of hydraulic lubricating oils can be re-refined after contamination, either at local refineries or with in-plant refining equipment.	<u>American Machinist</u> , Feb. 4, 1974, p. 50.	The Hilliard Corp., Elmira, NY. Donaldson Co., Inc., Liquid Systems Div., Minneapolis, MN. De Laval Separator Co., Poughkeepsie, NY.
	Heat reclamation of exhaust air	Recycling of contaminated or humid air from heat processing operations, ovens, driers, and all conventional heat-exhaust generating manufacturing processes. Manufacturers claim 40%-80% of heat otherwise wasted is recovered.	<u>Canadian Machinery and Metalworking</u> , Apr. 1976, pp. 30-31. (adv.)	Ontario Hydro
	Heat recuperation in annealing and other radiant tube-fired furnaces	Double-walled stack and burner should reduce heat loss; heat is held in center tube of stack and used to warm air. Manufacturers claim up to 75% reduction in furnace fuel consumption.	<u>American Machinist</u> , Aug. 1977, p. 49 <u>Iron Age</u> , July 18, 1977, p. 30.	Hague International, Portland, ME. Republic Steel, Cleveland, OH.

APPENDIX VI.2 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Recycling/Waste Control (cont.)	Heat recycling device	Device recovers and reuses risen heat which collects under ceilings and gables of large industrial areas; manufacturers claim 25%-30% reduction in plant heating fuel.	<u>Iron Age</u> , Jan. 12, 1976, p. 51.	Ramde Manufacturing Co., Cleveland, OH.
Reduce Initial Fuel Consumption	Electric Motors	Efficiency is improved by lengthened stator and rotor cores, addition of copper or aluminum to conductors, optimization of air gap, winding configuration and lamination geometry. Manufacturers claim up to 26.8% efficiency gain.	<u>American Machinist</u> , Dec. 1976, p. 167.	Gould, Inc.
	Air compressor	Air compressors use less energy than most efficient other screw compressors. Manufacturers claim energy savings of up to 20% using these devices.	<u>Iron Age</u> , Jan. 1, 1976, p. 150.	
	Natural gas burner	Natural gas burner uses extra-efficient heat transfer principle to save energy. Manufacturers claim 75%-85% efficiency vs. 55%-70% for ordinary burners.	<u>Iron Age</u> , Jan. 1, 1976, p. 163.	Basic Combustion Corp., Glen Ellyn, IL.
	Rapid heating box furnace	Utility box furnace used in heat processing of metals heats up and cools down in a "fraction" (value not specified) of the time of conventional brick furnaces.	<u>Production</u> , Jan. 1977, p. 94.	Lindberg, Div. of General Signal, Chicago, IL.

APPENDIX VI.2 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Reduce Initial Fuel Consumption (cont.)	Use roughing tools for heavy metal removal operations	Energy consumption (HP) in metal removal operations increases at only 70%-80% of the rate of increase in feeds/unit of time. Roughing tools enable feed rate increase as well as operation at reduced speed. Manufacturers claim as much as 50% increase in productivity, and 15%-30% reduction in energy use/unit of output.	<u>American Machinist</u> , Nov. 25, 1974, p. 75.	Weldon Tool Co., Cleveland, OH.
	Polyurethane finishing of metals	Polyurethane finishes can be air-dried at room temperature, reducing energy use substantially, as compared with baked enamel finishing which requires large amounts of heat. Manufacturers claim up to 60% savings in energy.	<u>American Machinist</u> , Nov. 1975, p. 53. <u>Iron Age</u> , Jan. 5, 1976, p. 76. <u>Iron Age</u> , Mar. 29, 1976, p. 40 (adv.). <u>Iron Age</u> , Sept. 20, 1976, pp. 32-33.	Sherwin Williams, Chemical Coatings Div., Cleveland, OH. Mobay Chemical Corp., Pittsburgh, PA.
	Use electrostatic paint sprayers for finishing metal surfaces	Electrostatic paint sprayers save fuel used in recirculation and reheating of air in spray booths by reducing volume of air needed to be recirculated. If electrostatic powder coating process is used instead of paint, no recirculation is necessary. Manufacturers claim 40%-100% reduction in fuel used to reheat air.		Nordson Corp., Amherst, OH

APPENDIX VI. 2 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Reduce Initial fuel Consumption (cont.)	Roll forming	Roll forming is the least energy-intensive of all metal forming operations, produces almost no scrap, and operates at room temperature. Can be used to corrugate, rib hem, curve, flute, and fold nearly all types of materials.	<u>Iron Age</u> , Feb. 2, 1976, p. 44. <u>Production</u> , Mar. 1977, pp. 55-59.	Wean United Tubular Bar and Machinery
	One-step metal shaping	Hydraulic press performs cold extrusions, producing no chips and replacing a series of machine-to-machine cutting operations. Energy used in heating, forging, and machining all eliminated.	<u>American Machinist</u> , Apr. 1977, p. SR-18.	Transmares Corp., Carteret, N.J.
	Low-temperature metalworking chemicals	Chemicals used to clean and coat metals are activated at low temperatures. Manufacturers claim they pay for themselves in fuel consumption reduction achieved by their use.	<u>Iron Age</u> , Jan. 5, 1976, p. 62 (adv.).	Amchem Products, Ambler, PA.
	Infra-red heating	Uses fuel more efficiently than conventional methods for spot-heating, space heating, and process heating in manufacturing.	<u>Iron Age</u> , Jan. 5, 1976, p. 146.	
	Fiber rolls for heat treating	Use mineral fiber rolls to replace water-cooled metallic rolls in the high temperature zone of a roller-hearth continuous heat-treating furnace.	<u>American Machinist</u> , July 22, 1974, p. 66.	Lubens Steel Co., Coatesville, PA.

APPENDIX VI.2 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Reduce Initial Fuel Consumption (cont.)	Energy-efficient induction hardening system	A gear-hardening system which is energy-efficient.	<u>Production</u> , Mar. 1977, p. 100.	Lindberg Heat Treatment, Chicago, IL.
	Hot rolled steel which needs no annealing in order to be drawn	Special process in which hot rolled steel can be punched and then drawn without requiring annealing between processes to reduce tear in punches. Eliminates fuel consumed by this energy-intensive heat-treating process.	<u>Iron Age</u> , Jan. 15, 1976, p. 113 (adv.).	Armco Steel Corp., Middletown, OH.
	Stressproof steel	Cold-finished steel bars said to require no heat treating for strength. Also said to be easily machined, for additional energy saving. Manufacturers claims 24%-61% less energy used in manufacturing process.	<u>Iron Age</u> , Jan. 12, 1976, p. 9 (adv.).	La Salle Steel, Hammond, IN.
	Energy-efficient conveyor system	Conveyor system can move greater loads at 0.5 HP than conventional slider-bed conveyors can at 1.5 HP. Manufacturers claim 65% reduction in HP requirements.	<u>Iron Age</u> , June 20, 1977.	Metzgar Conveyor Co.
	Energy-adaptive grinding	Use monitoring equipment and reduce power used through control of grinding heat, wheel velocity, metal removal, and grinding time. Manufacturer claims productivity increases by 50%-100%, and energy efficiency improvement of 80%.	<u>American Machinist</u> , July 1977, p. 115.	Energy-Adaptive Grinding, Inc., Rockford, IL.

APPENDIX VI. 2 (Cont'd)

OBJECTIVE	METHOD/DEVICE	DESCRIPTION	REFERENCES	REPRESENTATIVE MANUFACTURERS
Reduce Initial Fuel Consumption (cont.)	Computer-controlled load shedding	Computer monitors and predicts electricity demand peaks, and systematically shuts down select heavy consuming equipment (e.g., air conditioners) for short periods without affecting operations. Manufacturers claim demand peaks can be reduced by as much as 3,000 KWH.	<u>American Machinist</u> , Aug. 19, 1974, p. 53. <u>American Machinist</u> , Feb. 1, 1975, p. 51. <u>Iron Age</u> , July 29, 1974, p. 41.	IBM
Alternatives	Use nitrogen-based atmospheres in place of natural gas	Use industrial gases of nitrogen, hydrogen, and carbon dioxide instead of natural gas in heat-treating furnaces.	<u>American Machinist</u> , June 1977.	Air Products and Chemicals, Inc.
	Suspend in-house heat-treating.	Unless equipment is productive nearly 24 hours/day, it is often more economical and always fuel-conservative to subcontract to heat-treater.	<u>Iron Age</u> , June 13, 1977, p. 22 (adv.).	Lindberg Heat Treatment, Chicago, IL.
	Choose materials according to their energy requirements for processing	Consider energy cost as part of materials cost calculations; substitutions could save energy without sacrificing performance.	<u>Iron Age</u> , Mar. 29, 1976, pp. 40-41. <u>Iron Age</u> , June 13, 1977, pp. 39-52.	

APPENDIX VI.3

COMPUTERIZED LISTING OF TOPICAL ARTICLES

Print 6/5/1-8

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item

1 of 8) User4289 6sep77

58790 D7706039

ECONOMIES OF PRODUCTION IN THE USAGE OF NARROW STRIP

WOLSTENCROFT, J.

REDMAN ENGINEERING LTD., SWINDON, ENGLAND

SHEET MET. IND. (GB) VOL.54, NO.3 217-18, 221, 225

MARCH 1977 Coden: SHMIAR

Descriptors: SHEET METAL WORKING; PRODUCTION COSTS; PRESSING
; PRODUCTIVITY

Identifiers: ECONOMIES OF PRODUCTION; NARROW STRIP; COIL
HANDLING EQUIPMENT; CONTINUOUS STRIP PROCESSING LINES; POWER
PRESSES; PRESS TOOLING; COILED STRIP SLITTING LINES; SPECIAL
PURPOSE MACHINERY; STRIP COATING PROCESSES; COILED STRIP
STORAGE SYSTEMS; COILED STRIP SECTION FORMING LINES

02

Section Class Codes: D4350, D1360

58202 D7705451

BAR TRANSFERS IN THE MANUFACTURE OF COMPONENTS FROM NARROW
STRIP

LITTLEWOOD, M.

LOHR INTERNAT. LTD., SHEFFIELD, ENGLAND

SHEET MET. IND. (GB) VOL.54, NO.3 226 MARCH 1977

Coden: SHMIAR

Descriptors: HYDRAULIC POWER TRANSMISSION SYSTEMS; TRANSFER
LINES; PRESSES; SHEET METAL WORKING; DRIVES; DESIGN;
AUTOMATION

Identifiers: SALVAGNINI TRANSFERS; AUTOMATIC PRODUCTION;
HYDRAULIC DISTRIBUTOR; CARDAN SHAFT; HYDRAULIC POWER PACK; BAR
TRANSFERS; MANUFACTURE OF COMPONENTS; NARROW STRIP

02

Section Class Codes: D4350, D1360, D5590

58190 D7705439

SOME INVESTIGATIONS ON EXPLOSIVE FORMING WITH CONICAL DIES

BEHERA, T.; DAS, S.C.; BANERJEE, J.; MISRA, S.

REGIONAL ENGR. COLL., ROURKELA, INDIA

J. INST. ENGR. (INDIA) MECH. ENG. DIV. VOL.57, PT.ME-3

140-3 NOV. 1976 Coden: JEMDAS

(4 Refs)

Descriptors: HIGH ENERGY RATE FORMING; DIES; SHEET METAL
WORKING

Identifiers: AL; CU; BRASS; EXPLOSIVE FORMING; CONICAL DIES;
CORDTEX EXPLOSIVE; STAND OFF DISTANCE; SHEET METALS; STRAINS;
DEFORMED BLANKS

02

Section Class Codes: D4350

54320 D7701569

ELECTROHYDRAULIC FORMING OF SHEET METALS. I

SANO, T.

MECH. ENGRG. LAB., TOKYO, JAPAN

BULL. MECH. ENGR. LAB. (JAPAN) NO.25 1-12 1976 Coden:

BMEGAX

(6 Refs)

Descriptors: FORMING PROCESSES; SHEET METAL WORKING

Identifiers: ELECTROHYDRAULIC FORMING; SHEET METALS;

ELECTRICAL STORED ENERGY; PEAK PRESSURE; PRESSURE WAVE;

FREQUENCY COMPONENTS; BULGED HEIGHT

02

Section Class Codes: D4350

42419 D7604710

25000-TON HIGH ENERGY SHEET FORMING MACHINE

MACH. AND PROD. ENGR. (GB) VOL.128, NO.3301 257-8 17

MARCH 1976 Coden: IMPREAU

Descriptors: HIGH ENERGY RATE FORMING; FORMING EQUIPMENT;
SHEET METAL WORKING

Identifiers: 25000 TON HIGH ENERGY FORMING MACHINE; METAL
SHEET; EXPLOSIVE; CAPACITOR DISCHARGE; COMBUSTIBLE GAS; HIGH
PRESSURE WATER

02

Section Class Codes: D4350

42049 D7604340

MARKETS FOR ROLLED COPPER AND COPPER, ALLOYS

DAVIES, M.H.

SHEET MET. IND. (GB) VOL.53, NO.2 86-8 FEE. 1976

Coden: SHMIAR

Descriptors: COPPER; COPPER ALLOYS; ROLLING; MARKETING; SHIP
COMPONENTS; MOTOR VEHICLE COMPONENTS; BUILDING; ELECTRONIC
EQUIPMENT MANUFACTURE; SOLAR ENERGY; SHEET METAL WORKING
Identifiers: ROLLED CU; TRANSPORT APPLICATIONS; ROLLED CU
ALLOYS; BUILDING APPLICATIONS; CU IN STEELS; ELECTRICAL
APPLICATIONS; MARKETS; SOLAR HEATING; SHIPS HULLS; OIL
INDUSTRY; METHODS OF PROCESSING

02

Section Class Codes: D8710, D1140, D4350

19729 D7404723

MOBILITY AIDS PRODUCTION

MACH.-TOOL REV. (GB) VOL.62, NO.360 95 JULY-AUG. 1974

Coden: MCTBRN

Descriptors: SHEET METAL WORKING; HYDRAULIC POWER
TRANSMISSION SYSTEMS; DRIVES; FORMING EQUIPMENT
Identifiers: STRETCHING; NOTCHING; PUNCHING; SHEET METAL;
MOBILE FORMER; HYDRAULIC DRIVE; TOOLING; SHRINKING

02

Section Class Codes: D4350, D5590

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 8 of 8) User4289 6sep77

7756 D7400262

POWER PRESS GIVES TOP MILEAGE (FOR SHEET METAL WORKING)
ENGINEERING (GB) VOL.213, NO.11 791 NOV. 1973 Coden:
ENGNA2

Descriptors: PRESSES; SHEET METAL WORKING
Identifiers: POWER PRESS; SINGLE DIE; COMBINED BLANKING;
FORMING; SHALLOW DRAWING
02

Section Class Codes: D4350

APPENDIX VI.3 (Cont'd)

Print 11/5/1-63

DIALOG File 14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item

1 of 63) User4289 6sep77

60684 07700311

'METAL-CUTTING' ENERGY ABSORBERS

KIRK, J.A.; GAY, J.W.

UNIV. OF MARYLAND, COLLEGE PARK, MD, USA

MACH. DES. (USA) VOL.49, NO.5 84-5 10 MARCH 1977

Coden: MADEAP

Descriptors: CUTTING; DAMPING DEVICES

Identifiers: METAL CUTTING ENERGY ABSORBERS

02

Section Class Codes: D4410, D3740

60017 07707296

FOR FAST CLAMPING SETUPS

MANUF. ENG. (USA) VOL.78, NO.3 46-7 MARCH 1977

Descriptors: WORK HOLDERS; HYDRAULIC EQUIPMENT; JIGS AND FIXTURES

Identifiers: DRILLING; MILLING; FIXTURE; MACHINE TOOLS; FAST CLAMPING SETUPS; WORK HOLDING TOOLS; HYDRAULIC POWER

02

Section Class Codes: D4410

60014 07707293

CLAMPING HARD-TO-HOLD PARTS

MANUF. ENG. (USA) VOL.78, NO.3 43-4 MARCH 1977

Descriptors: WORK HOLDERS

Identifiers: MACHINE TOOLS; CLAMPING; UNIVERSAL POWER FINGER CHUCK; DESIGN

02

Section Class Codes: D4410

58790 07706039

ECONOMIES OF PRODUCTION IN THE USAGE OF NARROW STRIP

WOLSTENCROFT, J.

REDMAN ENGINEERING LTD., SWINDON, ENGLAND

SHEET MET. IND. (GB) VOL.54, NO.3 217-18, 221, 225

MARCH 1977 Coden: SHMTAR

Descriptors: SHEET METAL WORKING; PRODUCTION COSTS; PRESSING ; PRODUCTIVITY

Identifiers: ECONOMIES OF PRODUCTION; NARROW STRIP; COIL HANDLING EQUIPMENT; CONTINUOUS STRIP PROCESSING LINES; POWER PRESSES; PRESS TOOLING; COILED STRIP SLITTING LINES; SPECIAL PURPOSE MACHINERY; STRIP COATING PROCESSES; COILED STRIP STORAGE SYSTEMS; COILED STRIP SECTION FORMING LINES

02

Section Class Codes: D4350, D1360

58245 07705494

VI.3-3

HIGH PURITY STEEL FOR STRONGER GEARS (IN METAL-CUTTING MACHINE TOOLS)

STANKI AND INSTRUM. (USSR) VOL.47, NO.1 16-17 1976

Coden: STINA4

Trans of: MACH. AND TOOL. (GB) VOL.47, NO.1 22-3 1976

Coden: MCTOAD

(4 Refs)

Descriptors: STEEL; MECHANICAL STRENGTH; GEARS; MACHINE TOOL COMPONENTS

Identifiers: HIGH PURITY STEEL; ELECTROSLAG REMELTED STEEL; POWER TRANSMISSION GEARS; METAL CUTTING MACHINE TOOLS; TOOTH BENDING STRENGTH

02

Section Class Codes: D4410, D5530, D3260

58202 07705451

BAR TRANSFERS IN THE MANUFACTURE OF COMPONENTS FROM NARROW STRIP

LITTLEWOOD, M.

LOMIR INTERNAT. LTD., SHEFFIELD, ENGLAND

SHEET MET. IND. (GB) VOL.54, NO.3 226 MARCH 1977

Coden: SHMIAR

Descriptors: HYDRAULIC POWER TRANSMISSION SYSTEMS; TRANSFER LINES; PRESSES; SHEET METAL WORKING; DRIVES; DESIGN; AUTOMATION

Identifiers: SALVAGNINI TRANSFERS; AUTOMATIC PRODUCTION; HYDRAULIC DISTRIBUTOR; CARDAN SHAFT; HYDRAULIC POWER PACK; BAR TRANSFERS; MANUFACTURE OF COMPONENTS; NARROW STRIP

02

Section Class Codes: D4350, D1360, D5590

58190 07705439

SOME INVESTIGATIONS ON EXPLOSIVE FORMING WITH CONICAL DIES

BEHERA, T.; DAS, S.C.; BANERJEE, J.; MISRA, S.

REGIONAL ENGG. CCLL., ROURKELA, INDIA

J. INST. ENG. (INDIA) MECH. ENG, DIV. VOL.57, FT.ME-3

140-3 NOV. 1976 Coden: JEMDAS

(4 Refs)

Descriptors: HIGH ENERGY RATE FORMING; DIES; SHEET METAL WORKING

Identifiers: AL; CU; BRASS; EXPLOSIVE FORMING; CONICAL DIES; CORDTEX EXPLOSIVE; STAND OFF DISTANCE; SHEET METALS; STRAINS; DEFORMED BLANKS

02

Section Class Codes: D4350

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 8 of 63) User4289 6sep77

56926 07704245
HUGE MACHINE TOOLS PRODUCE NUCLEAR VESSELS
SHAH, R.
IRON AGE METALWORK. INT. (USA) VOL.16, NO.1 19-20 JAN.
1977 Coden: IAMIA4
Descriptors: NUCLEAR REACTOR COMPONENTS; MILLING MACHINE
TOOLS; BORING MACHINE TOOLS; DRILLING MACHINE TOOLS
Identifiers: BORING MACHINE; 300 TON WORKPIECE; PLATE BENDER
; NUCLEAR VESSELS; MILLING MACHINES; NC DEEPHOLE DRILLING
MACHINE; NUCLEAR POWER PLANTS; ROTARY TABLE
02
Section Class Codes: D4410, D8100

54320 07701569
ELECTROHYDRAULIC FORMING OF SHEET METALS. I
SANO, T.
MECH. ENNG. LAB., TOKYO, JAPAN
BULL. MECH. ENG. LAB. (JAPAN) NO.25 1-12 1976 Coden:
BMEGAX
(6 Refs)
Descriptors: FORMING PROCESSES; SHEET METAL WORKING
Identifiers: ELECTROHYDRAULIC FORMING; SHEET METALS;
ELECTRICAL STORED ENERGY; PEAK PRESSURE; PRESSURE WAVE;
FREQUENCY COMPONENTS; BULGED HEIGHT
02
Section Class Codes: D4350

51811 07606628
HARDWIRED LOGIC FOR THE ADAPTIVE CONTROL OF A MILLING
MACHINE
BEDINI, R.; PINOTTI, P.C.
ISTITUTO DI INGEGNERIA MECCANICA, UNIV. DI FIRENZE, FIRENZE,
ITALY
INT. J. MACH. TOOL DES. AND RES. (GB) VOL.16, NO.3
193-207 1976 Coden: IUTDAJ
(19 Refs)
Descriptors: MILLING MACHINE TOOLS; MACHINE TOOL CONTROL;
TRANSDUCERS
Identifiers: HARDWIRED LOGIC; ADAPTIVE CONTROL; MILLING
MACHINE; DEVELOPMENTS; ON LINE CONTROL; OPTIMIZATION;
NUMERICALLY CONTROLLED MACHINING CENTRE; TRANSDUCERS; TORQUE;
POWER; PRODUCTIVITY; MEASURING
02
Section Class Codes: D4410

50697 07605434
THE SPEED SPECIALISTS' CONTRIBUTION TO NAVAL POWER. (DIAMOND
TOOLING ROLE IN PRODUCTION OF OLYMPUS FLARE)
HEBERT, S.
IND. DIAMOND REV. (GB) 358-9 OCT. 1976 Coden: INDRA9

(2 Refs)
Descriptors: GAS TURBINES; MARINE ENGINES; MILITARY SHIPS;
REINFORCED PLASTICS; COMPOSITE MATERIALS TECHNOLOGY; MOULDING;
DIAMOND TOOLS; DRILLING MACHINE TOOLS
Identifiers: DIAMOND TOOLING; NAVAL POWER; OLYMPUS MARINE
GAS TURBINE; MAIN PROPULSION UNIT; WARSHIPS; MANUFACTURE;
INTAKE FLARE; PRECISION MOULDING; GLASS REINFORCED PLASTIC
02
Section Class Codes: D5420, D9100, D4410, D4370

50546 07605283
METHODS OF STORING INFORMATION IN MEMORY UNITS TO CONTROL
UNIT-CONSTRUCTION MACHINE TOOLS AND AUTOMATIC LINES
PETIMKO, I.I.
STANKI AND INSTRUM. (USSR) VOL.46, NO.10 1-4 1975
Coden: STINA4
Trans of: MACH. AND TOOL. (GB) VOL.46, NO.10 3-7 1975
Coden: MCTOAD
(5 Refs)
Descriptors: MACHINE TOOL CONTROL; CONTROL SYSTEMS
Identifiers: CONTROL; AUTOMATIC LINES; STORING INFORMATION;
MEMORY CELLS; INTERRUPTIONS IN POWER SUPPLY; TRANSISTORISED
UNITS; LOGIKA T SERIES; UNIT CONSTRUCTION MACHINE TOOLS
02
Section Class Codes: D4400, D2490

48053 07602790
A BRIEF VIEW OF THE SWEDISH MACHINE-TOOL INDUSTRY. II
MACH. AND PROD. ENG. (GB) VOL.129, NO.3321 106-10 4
AUG. 1976 Coden: MPREAU
Descriptors: MACHINE TOOLS
Identifiers: CENTRELESS GRINDING MACHINES; MILLING MACHINES;
NC; MACHINE TOOL INDUSTRY; SWEDEN; POWER PRESS
02
Section Class Codes: D4400

- DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 14 of 63) User4289 6sep77
- 46821 D7601558
ROTOR SLOT MILLER CUTS MACHINING TIME (FOR NUCLEAR POWER PLANT ROTORS)
SWAN, R.
IRON AGE METALWORK. INT. (USA) VOL.15, NO.5 31 MAY 1976 Coden: IAMIA4
Descriptors: MILLING MACHINE TOOLS; SHAFTS; MACHINE TOOL CONTROL; NUCLEAR POWER STATIONS; PRODUCTION COSTS; PRODUCTIVITY
Identifiers: PRODUCTION TIME SAVINGS; LARGE DIAMETER DISC TYPE CUTTERS; ROTOR SLOT MILLER; MACHINING TIME; COST SAVINGS; NUCLEAR POWER PLANT ROTORS; ACCURATE ALIGNMENT; ACCURATE INDEXING
02
Section Class Codes: D4410, D8100, D1360, D5510
- 46219 D7600956
HYDROSTATIC AXIAL PISTON UNITS FOR METAL-CUTTING MACHINES
SWEKAL, R.
TZ PRAKT. METALLBEARB. (GERMANY) VOL.70, NO.4 117-22 APRIL 1976 Coden: TZPMBM
Descriptors: MACHINE TOOLS; HYDRAULIC POWER TRANSMISSION SYSTEMS
Identifiers: METAL CUTTING MACHINES; HYDROSTATIC AXIAL PISTON UNITS; DRIVES; GRINDING MACHINES; PLANING MACHINES; NOISE DEVELOPMENT; PUMPS; MOTORS; HYDRAULIC TRANSMISSION; INCLINED SHAFT; SWASH PLATE DESIGN; PRESSES
02
Section Class Codes: D4410, D5590
Language: GERMAN
- 46197 D7600934
AUTOMATION OF WHEEL FEED IN SLIDEWAY GRINDERS (WITH POWER SERVOSYSTEM)
STANKI AND INSTRUM. (USSR) VOL.46, NO.7 9-11 1975 Coden: STINA4
Trans of: MACH. AND TOOL. (GB) VOL.46, NO.7 15-18 1975 Coden: MCTOAD
(1 Refs)
Descriptors: GRINDING MACHINE TOOLS; SERVOMECHANISMS; AUTOMATION
Identifiers: MICROFEED; AUTOMATION; WHEEL FEED; SLIDEWAY GRINDERS; MECHANISM; HEAD POSITIONING; POWER SERVOSYSTEM; THYRISTOR DRIVE; PLUNGING
02
Section Class Codes: D4410, D2450
- 46193 D7600930
RIGHT COORDINATION (OF MACHINE TOOLS) SPELLS PRODUCTIVITY (FOR TRUCK TRANSMISSION PLANT)
- WEST, B.
MOD. MACH. SHOP (USA) VOL.48, NO.12 84-8 MAY 1976 Coden: MCHASAY
Descriptors: MACHINE TOOLS; PRODUCTIVITY; MECHANICAL POWER TRANSMISSION SYSTEMS
Identifiers: MACHINE TOOLS; WORK FLOW; OPTIMUM PRODUCTIVITY; TRUCK TRANSMISSION PLANT
02
Section Class Codes: D4410, D1360, D5590
- 45518 D7600255
PNEUMATIC LOGIC-AN ANSWER TO PRODUCTIVITY. (UNIVERSAL DRILLING AND TAPPING MACHINE FOR MACHINING OF MEDICAL INSTRUMENTS)
SPINALE, J.R.
ILLINOIS INST. TECHNOL., FLUID POWER SOC., NAT. FLUID POWER ASSOC.
31ST NATIONAL CONFERENCE ON FLUID POWER 471-5 1975 21-23 OCT. 1975 CHICAGO, ILL., USA
ILLINOIS INST. TECHNOL. CHICAGO, ILL., USA
Descriptors: MACHINING CENTRES; MACHINE TOOL CONTROL; PNEUMATIC CONTROL EQUIPMENT; BIOMEDICAL EQUIPMENT; PRODUCTIVITY; DRILLING MACHINE TOOLS; FLUIDICS
Identifiers: MACHINING CENTRE; PNEUMATIC LOGIC; PRODUCTIVITY ; MEDICAL INSTRUMENTS; UNIVERSAL DRILLING AND TAPPING MACHINE
06
Section Class Codes: D4410, D1360, D2600, D8600
- 44300 D7606591
STATISTICAL ANALYSIS OF THE CHARACTERISTICS OF ELECTRICAL DRIVES ON SURFACE GRINDING MACHINES
MEISTEL, A.M.
STANKI AND INSTRUM. (USSR) VOL.46, NO.6 10-12 1975 Coden: STINA4
Trans of: MACH. AND TOOL. (GB) VOL.46, NO.6 15-18 1975 Coden: MCTOAD
(3 Refs)
Descriptors: STATISTICS; GRINDING MACHINE TOOLS; DRIVES; ELECTRIC MOTORS
Identifiers: MOTORS; STATISTICAL ANALYSIS; ELECTRICAL DRIVES ; SURFACE GRINDING MACHINES; HISTOGRAMS; POWER
02
Section Class Codes: D4410, D8250

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 20 of 63) User4289 6sep77

44272 D7606563
 PROXIMITY-TYPE LOGIC COMPONENTS FOR THE CONTROL CIRCUITS OF
 UNIT-CONSTRUCTION MACHINE TOOLS
 BRAUN, M.N.
 STANKI AND INSTRUM. (USSR) VOL.46, NO.6 7-10 1975
 Coden: STINA4
 Trans of: MACH. AND TOOL. (GB) VOL.46, NO.6 11-14 1975
 Coden: MCTOAD
 (2 Refs)
 Descriptors: MACHINE TOOL CONTROL
 Identifiers: PROXIMITY TYPE LOGIC COMPONENTS; CONTROL
 CIRCUITS; POWER SUPPLIES; LOGIKA-T SYSTEM; UNIT CONSTRUCTION
 MACHINE TOOLS
 02
 Section Class Codes: D4400

43818 D7606109
 NON-CONTACT FREE-WHEEL CLUTCHES WITH CYLINDRICAL ROLLERS
 MALTSEV, V.F.
 STANKI AND INSTRUM. (USSR) VOL.46, NO.5 14-16 1975
 Coden: STINA4
 Trans of: MACH. AND TOOL. (GB) VOL.46, NO.5 24-7 1975
 Coden: MCTOAD
 (3 Refs)
 Descriptors: MACHINE TOOL COMPONENTS; CLUTCHES
 Identifiers: NONCONTACT FREE WHEEL CLUTCHES; CYLINDRICAL
 ROLLERS; ENERGY LOSSES IN IDLING; METAL CUTTING MACHINE TOOLS
 02
 Section Class Codes: D5510, D4410

43635 D7605976
 DEVICES FOR AUTOMATIC TOOL-LOAD CONTROL
 PRAPIS, L.M.
 STANKI AND INSTRUM. (USSR) VOL.46, NO.5 26-7 1975
 Coden: STINA4
 Trans of: MACH. AND TOOL. (GB) VOL.46, NO.5 42-4 1975
 Coden: MCTOAD
 (3 Refs)
 Descriptors: MACHINE TOOL CONTROL; FORCE CONTROL
 Identifiers: DEVICES; TOOL LOAD CONTROL; AUTOMATIC LINES;
 MACHINE TOOLS; MOTOR CURRENT; POWER FACTOR COMPENSATION;
 TORQUE; THRUST
 02
 Section Class Codes: D4410, D2260

43196 D7605487
 PROBLEMS OF HIGH SPEED HYDRAULIC OPERATION (MACHINE TOOLS
 EXAMPLE)
 TOWN, H.C.
 HYDRAUL. PNEUM. MECH. POWER (GB) VOL.22, NO.255 87-9

MARCH 1976 Coden: HPMPDK
 Descriptors: HYDRAULIC POWER TRANSMISSION SYSTEMS; MACHINE
 TOOLS
 Identifiers: CYLINDER ARRANGEMENTS; ROTARY DRIVE; BRCACHING
 MACHINE; HIGH SPEED HYDRAULIC OPERATION; MACHINE TOOL
 02
 Section Class Codes: D5590, D4410

42419 D7604710
 25000-TON HIGH ENERGY SHEET FORMING MACHINE
 MACH. AND PROD. ENG. (GB) VOL.128, NO.3301 257-8 17
 MARCH 1976 Coden: MPREAU
 Descriptors: HIGH ENERGY RATE FORMING; FORMING EQUIPMENT;
 SHEET METAL WORKING
 Identifiers: 25000 TON HIGH ENERGY FORMING MACHINE; METAL
 SHEET; EXPLOSIVE; CAPACITOR DISCHARGE; COMBUSTIBLE GAS; HIGH
 PRESSURE WATER
 02
 Section Class Codes: D4350

42389 D7604680
 THE USE OF DECELERATIVE METAL CUTTING IN THE DESIGN OF
 ENERGY-MANAGEMENT SYSTEMS
 PLECK, M.H.; METZ, L.D.; CONRY, T.F.
 DEPT. OF GENERAL ENGN., UNIV. OF ILLINOIS,
 URBANA-CHAMPAIGN, IL, USA
 TRANS. ASME SER. B (USA) VOL.97, NO.3 867-72 AUG. 1975
 Coden: JEFIAB
 (52 Refs)
 Descriptors: CUTTING; ENERGY STORAGE COMPONENTS; DESIGN;
 DAMPING DEVICES
 Identifiers: ENERGY MANAGEMENT SYSTEMS; MINIMUM STROKE
 ENERGY ABSORBING DEVICES; DECELERATIVE METAL CUTTING; DESIGN
 02
 Section Class Codes: D3740, D4410

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 26 of 63) User4289 6sep77

422-12 D7604533

DAMPING AT METALLIC INTERFACES SUBJECTED TO OSCILLATING
TANGENTIAL LOADS. (MACHINE TOOL VIBRATION)

ROGERS, P.F.; BOOTHROYD, G.

UNIMATION INC., DANBURY, CT, USA

TRANS. ASME SER. B (USA) VOL.97, NO.3 1087-93 AUG.

1975 Coden: JEFIA8

(8 Refs)

Descriptors: DAMPING; VIBRATIONS; MACHINE TOOLS

Identifiers: DAMPING; METALLIC INTERFACES; OSCILLATING

TANGENTIAL LOADS; ENERGY LOSS PER CYCLE; BOLTED JOINTS;

MACHINE TOOLS; VIBRATIONS; CHATTER

02

Section Class Codes: D3220, D4410

420-19 D7604340

MARKETS FOR ROLLED COPPER AND COPPER ALLOYS

DAVIES, M.H.

SHEET MET. IND. (GB)

VOL.53, NO.2 86-8 FEB. 1976

Coden: SHMIAR

Descriptors: COPPER; COPPER ALLOYS; ROLLING; MARKETING; SHIP

COMPONENTS; MOTOR VEHICLE COMPONENTS; BUILDING; ELECTRONIC

EQUIPMENT MANUFACTURE; SOLAR ENERGY; SHEET METAL WORKING

Identifiers: ROLLED CU; TRANSPORT APPLICATIONS; ROLLED CU

ALLOYS; BUILDING APPLICATIONS; CU IN STEELS; ELECTRICAL

APPLICATIONS; MARKETS; SOLAR HEATING; SHIPS HULLS; OIL

INDUSTRY; METHODS OF PROCESSING

02

Section Class Codes: D8710, D1140, D4350

40719 D7603010

HYDROSTATIC TRANSMISSIONS

LEDOCCQ, J.

FACULTE POLYTECH. DE MONS, MONS, BELGIUM

REV.-M (BELGIUM) VOL.21, NO.4 331-8

DEC. 1975 Coden:

RMRTAK

Descriptors: HYDRAULIC POWER TRANSMISSION SYSTEMS; HYDRAULIC

MOTORS; PUMPS

Identifiers: RIGIDITY; FREEDOM OF INSTALLATION; HIGH

TRANSMISSION RATIO; HIGH EFFICIENCY; EARTH MOVING EQUIPMENT;

PRECISION MACHINE TOOLS

02

Section Class Codes: D5590

Language: FRENCH

39878 D7602169

NUMERICAL ANALYSIS OF TEMPERATURE DISTRIBUTION IN THREE

DIMENSIONAL METAL CUTTING

USUI, E.; SHIRAKASHI, T.; KITAGAWA, T.

J. JAP. SOC. PRECIS. ENG. (JAPAN) VOL.41, NO.12 1141-6

DEC. 1975 Coden: JUPEAD

(8 Refs)

Descriptors: CUTTING; MODELLING; TEMPERATURE DISTRIBUTION;
NUMERICAL ANALYSIS

Identifiers: NUMERICAL ANALYSIS; TEMPERATURE DISTRIBUTION;

THREE DIMENSIONAL METAL CUTTING; SINGLE POINT TOOL; ORTHOGONAL

CUTTING DATA; CUTTING FORCE; CHIP FORMATION; CHIP FLOW

DIRECTION; SHEAR ANGLE; CHIP SHAPE; TOOL OF ARBITRARY SHAPE;

FRICTIONAL STRESS DISTRIBUTION; RAKE FACE; ENERGY METHOD;

STRENGTH OF HEAT SOURCES; CUTTING MODEL

02

Section Class Codes: D4410, D3310

Language: JAPANESE

39870 D7602161

COMPUTER AIDED DESIGN OF MACHINE STRUCTURES WITH RESPECT TO

STATIC AND DYNAMIC CHARACTERISTICS BY SYNTHESIS OF DYNAMIC

RIGIDITY PROGRAM SYSTEM. III. STUDY FOR ANALYSIS OF STRUCTURAL

DYNAMICS OF MACHINE TOOLS

YOSHIMURA, M.

J. JAP. SOC. PRECIS. ENG. (JAPAN) VOL.41, NO.11 1060-5

NOV. 1975 Coden: JUPEAD

(9 Refs)

Descriptors: MACHINE TOOLS; COMPUTER-AIDED DESIGN;

VIBRATIONS; OPTIMISATION

Identifiers: STATIC CHARACTERISTICS; COMPUTER AIDED DESIGN;

MACHINE STRUCTURES; DYNAMIC CHARACTERISTICS; SYNTHESIS;

DYNAMIC RIGIDITY PROGRAM SYSTEM; ANALYSIS OF STRUCTURAL

DYNAMICS; MACHINE TOOLS; OPTIMUM MACHINE; FREQUENCY RESPONSES;

NATURAL FREQUENCIES; MODE SHAPES; ENERGY DISTRIBUTIONS; MODAL

FLEXIBILITIES; OPTIMISATION PROCESS; MAXIMUM COMPLIANCE;

RELATIVE DISPLACEMENT; STATIC RIGIDITIES

02

Section Class Codes: D4410, D3220, D1340

Language: JAPANESE

34889 D7504714

POWER REDUCTION THROUGH EFFICIENT CHIP CONTROL

BATOR, J.S.

KENNAMETAL INC., LATROBE, PA, USA

CUTTING TOOL ENG. (USA) VOL.27, NO.7-8 4-8 JULY-AUG.

1975 Coden: CTEGAP

(6 Refs)

Descriptors: CUTTING

Identifiers: POWER REDUCTION; CHIP CONTROL; METAL CUTTING;

LAND ANGLE TOOL GEOMETRY

02

Section Class Codes: D4410

APPENDIX VI.3 (Cont'd)

VI.3-8

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 32 of 63) User4289 6sep77

33645 D7503480
MILLING WITH HIGHER CUTTING POWER AND WITH A SIGNIFICANTLY
EXTENDED RANGE OF APPLICATION
HAUSER, K.
MASCHINENMARKT (GERMANY) VOL.81, NO.24 403-4 25 MARCH
1975 Coden: MAMKAK
Descriptors: MILLING MACHINE TOOLS
Identifiers: MILLING; HIGHER CUTTING POWER; MACHINES; DESIGN;
CONSTRUCTION; RIGIDITY; HORIZONTAL MILLER; AUTOMATIC CUT
DOWN; CLIMB MILLING DEVICE; DIVIDING HEAD; DRIVE; SPINDLE
02
Section Class Codes: D4410
Language: GERMAN

32230 D7502055
COMPUTER ANALYSIS OF VIBRATION TRACES FOR INVESTIGATION OF
DISSIPATION OF ELASTIC ENERGY
GROMAKOVSKI, D.G.
VESTN. MASHINOSTR. (USSR) VOL.54, NO.10 34-6 1974
Coden: VMA5AV
Trans of: RUSS. ENG. J. (GB) VOL.54, NO.10 34-5 1974
Coden: RENJA3
Descriptors: DAMPING; VIBRATIONS; COMPUTER APPLICATIONS;
MECHANISMS
Identifiers: MACHINE TOOLS; MECHANISMS; COMPUTER ANALYSIS;
VIBRATION TRACES; DISSIPATION OF ELASTIC ENERGY; DAMPING;
SLIDES
02
Section Class Codes: D3220, D3720

30514 D7500339
PACKAGED (PNEUMATIC) SYSTEMS FOR AUTOMATING LIGHT DRILLING
MACHINES
ENG. DIG. (GB) VOL.36, NO.4 63 APRIL 1975 Coden:
ENDJAY
Descriptors: DRILLING MACHINE TOOLS; AUTOMATION; PNEUMATIC
POWER TRANSMISSION SYSTEMS
Identifiers: PACKAGED PNEUMATIC SYSTEM; LIGHT PILLAR TYPE
DRILLING MACHINES; AIR CYLINDER; AUTOMATING
02
Section Class Codes: D4410, D5590

27945 D7505350
DESIGN OF SWARF COLLECTORS FOR DRILLS
RIABOV, A.V.
STANKI AND INSTRUM. (USSR) VOL.45, NO.5 20 1974
Coden: STINA4
Trans of: MACH. AND TOOL. (GB) VOL.45, NO.5 32-3 1974
Coden: MCTOAD
(2 Refs)

Descriptors: DRILLING MACHINE TOOLS; DUST
Identifiers: DUST; DESIGN; SWARF COLLECTORS; DRILLS; OPTIMUM
WIDTH; HEIGHT; SUCTION POWER
02
Section Class Codes: D4410, D7836

26649 D7504014
STUDY OF OIL PERFORMANCE IN NUMERICALLY CONTROLLED HYDRAULIC
SYSTEMS
ROBERTSON, R.S.; ALLEN, J.M.
MOBIL OIL CORP., PRINCETON, N.J., USA
ILLINOIS INST. TECHNOLOG., ET AL
PROCEEDINGS OF THE NATIONAL CONFERENCE ON FLUID POWER
435-54 1974
12-13 NOV. 1974 PHILADELPHIA, PA., USA
NAT. CONFERENCE ON FLUID POWER CHICAGO, ILL., USA
Descriptors: NUMERICAL CONTROL; HYDRAULIC POWER TRANSMISSION
SYSTEMS; OIL; MACHINE TOOLS
Identifiers: PERFORMANCE; NUMERICALLY CONTROLLED; HYDRAULIC
SYSTEMS; HYDRAULIC CIR
06
Section Class Codes: D4400, D5590

24792 D7502157
FLUID POWER AND AUXILIARY MACHINE TOOL EQUIPMENT
TOWN, H.C.
HYDRAUL. PNEUM. POWER (GB) VOL.20, NO.239 411-14 NOV.
1974 Coden: HYPPAR
Descriptors: MACHINE TOOL COMPONENTS; HYDRAULIC EQUIPMENT
Identifiers: WORK HOLDING; ROTARY TABLES; ACCUMULATORS;
SAFETY DEVICES; INSPECTION; HYDRAULIC POWER; DRIVING; FEED
MOTIONS; MACHINE TOOLS; LATHE; GRINDING; TAILSTOCKS; CLAMPING;
PEDAL OPERATED; VALVE; COLLETS; CHUCK
02
Section Class Codes: D4400, D5500

24197 D7501562
FUTURMILL OPEN-SIDE PLANNER MILLS
MANUF. ENG. AND MANAGE. (USA) VOL.73, NO.4 11 OCT.
1974 Coden: MFEMAL
Descriptors: MILLING MACHINE TOOLS
Identifiers: OPEN SIDED; PLANNER MILLS; POWER; RIGIDITY;
VERSATILITY; COST; MILLING; DRILLING; TAPPING; BORING HEADS;
ATTACHMENTS
02
Section Class Codes: D4410

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 39 of 63) User4289 6sep77

23812 07501177
AUTOMATIC CONTROL OF A LABORATORY DIAMOND DRILLING MACHINE
AND PROSPECTS FOR FIELD APPLICATIONS
EVERELL, M.D.; TURCOTTE, G.; FORTIER, G.; BOISVERT, M.
DEPT. ENERGY, MINES AND RESOURCES, QUEBEC CITY, CANADA
IND. DIAMOND REV. (GB) 398-405 NOV. 1974 Coden: INDRA9
(4 Refs)
Descriptors: MACHINE TOOL CONTROL; DRILLING MACHINE TOOLS;
DIAMOND TOOLS; AUTOMATIC CONTROL; MINING EQUIPMENT
Identifiers: AUTOMATIC CONTROL; LABORATORY DIAMOND DRILLING
MACHINE; FIELD APPLICATIONS; THRUST; POWER; BIT; RATE;
PENETRATION; DISTANCE; FLUID; WEAR; PROGRAMMED; ADJUST
02
Section Class Codes: 07300, D4410

21662 07406656
NATURE OF WEAR IN A (MACHINE TOOL) LEADSCREW-NUT
TRANSMISSION
GRIBALLO, A.P.
STAND AND INSTRUM. (USSR) NO.1 21-2 1974 Coden:
STIN44
Trans of: MACH. AND TOOL. (GB) VOL.45 NO.1 37-9 1974
Coden: MCTO4D
(2 Refs)
Descriptors: OIL; LUBRICANTS; MECHANICAL POWER TRANSMISSION
SYSTEMS; WEAR; MACHINE TOOL COMPONENTS
Identifiers: MACHINE TOOLS; LEADSCREW NUT TRANSMISSION;
NATURE; WEAR; SLIDING TYPE; OIL; METALLIC LUBRICANTS;
RESISTANCE; THREAD WORKING SURFACES
02
Section Class Codes: D4400, D5590, D3650, D3690

19802 07404796
HYDROMECHANICAL DRIVE FOR DEEPER AND FASTER CUTS
FAOST, B.L.
CARRK EQUIPMENT CO., JACKSON, MICH., USA
TOOL. AND PROD. (USA) VOL.40, NO.5 76-8 AUG. 1974
Coden: TOPRAR
Descriptors: CUTTING TOOLS; MECHANICAL POWER TRANSMISSION
SYSTEMS; HYDRAULIC POWER TRANSMISSION SYSTEMS
Identifiers: INFINITELY VARIABLE SPEED; HYDROMECHANICAL
DRIVE UNIT; DEEPER CUTS; CUTTING SPEEDS; MACHINE TOOLS; POWER
SPLITTING; OPERATION; DESIGNS
02
Section Class Codes: D4410, D5590

19759 07404753
5TH GENERATION NC (FOR MACHINE TOOLS) DESIGNED WITH USER IN
MIND
BERRY, S.A.

BENDIX CORP., DETROIT, MICH., USA
TOOL. AND PROD. (USA) VOL.40, NO.5 81-2 AUG. 1974
Coden: TOPRAR
Descriptors: NUMERICAL CONTROL; MACHINE TOOLS; PRODUCTION
DESIGN
Identifiers: NUMERICAL CONTROL SYSTEMS; MACHINE TOOL;
COMPONENT; COST; MEMORIES; POWER CONSUMING; SOLID STATE
DEVICES; MSI INTEGRATED CIRCUITS
02
Section Class Codes: D4400, D1340

19729 07404723
MOBILITY AIDS PRODUCTION
MACH.-TOOL REV. (GB) VOL.62, NO.360 95 JULY-AUG. 1974
Coden: MCTRBN
Descriptors: SHEET METAL WORKING; HYDRAULIC POWER
TRANSMISSION SYSTEMS; DRIVES; FORMING EQUIPMENT
Identifiers: STRETCHING; NOTCHING; PUNCHING; SHEET METAL;
MOBILE FORMER; HYDRAULIC DRIVE; TOOLING; SHRINKING
02
Section Class Codes: D4350, D5590

19166 07404160
FLUID POWER IN THE MACHINE TOOL INDUSTRY
YOUNG, A.G.
FLUID POWER INT. (GB) VOL.39, NO.7 17, 19, 21, 23, 25.
27, 29-30 JULY-AUG. 1974 Coden: FLPIAT
(4 Refs)
Descriptors: MACHINE TOOLS; FLUID POWER TRANSMISSION SYSTEMS;
; POLLUTION
Identifiers: TERCTECHNOLOGY; NOISE; HEAT GENERATION; USES;
FLUID POWER; COMPONENTS; SYSTEMS; COSTS; APPLICATION; MACHINE
TOOLS; NOISE; POLLUTION; HYDRAULICS; PNEUMATICS
02
Section Class Codes: D4400, D5590

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 45 of 63) User4289 6sep77

19040 D7404074
TEMPERATURE AND NOISE PROFILES IN AN ARGON PLASMA JET
MANWELL, R.W.; RUDDY, M.J.
UNIV. LEICESTER, ENGLAND
IEL, IEEE, ET AL
SER: 0 85296131 6
3RD INTERNATIONAL CONFERENCE ON GAS DISCHARGES 611-14
1974
9-12 SEPT. 1974 LONDON, ENGLAND
IEE LONDON, ENGLAND
(4 Refs)
Descriptors: JETS; NOISE; TEMPERATURE DISTRIBUTION
Identifiers: NOISE PROFILES; ARGON; PLASMA JET; WELDING;
METAL CUTTING; CLEANING; HIGH TEMPERATURE CHEMICAL; ENERGY;
SPECTES TRANSFER; TRANSPORT PROPERTIES; TEMPERATURE PROFILES;
METALLURGICAL PROCESSES
00
Section Class Codes: D3510, D3310

17233 D7402227
TRANSIENT-PROCESS DYNAMICS IN HYDRAULIC MACHINE TOOLS
DEKISHNER, E.P.
STANKI AND INSTRUM. (USSR) NO.11 11-13 1973 Coden:
STIN44
Trans of: MACH. AND TOOL. (GB) VOL.44, NO.11 17-20
1973 Coden: MCTOAD
(4 Refs)
Descriptors: HYDRAULIC POWER TRANSMISSION SYSTEMS; MACHINE
TOOLS
Identifiers: HYDRAULIC MACHINE TOOLS; CHANGE OF SPEED; POWER
UNIT; FAST TRAVEL; WORKING FEED RATE; RECOIL; OPERATING
MECHANISM; FEED DRIVES; TRANSIENT PROCESS DYNAMICS; TWO STAGE
SPEED REDUCTION
02
Section Class Codes: D4400, D5590

14678 D7407184
TOOLING UP A GIANT 'SPECIAL' (BORING MACHINE FOR POWER
GENERATION EQUIPMENT)
SMITH, B.C.
FARREL CO., ROCHESTER, N.Y., USA
AM. MACH. (USA) VOL.118, NO.9 39-42 29 APRIL 1974
Coden: AMMAAA
Descriptors: BORING MACHINE TOOLS; CUTTING TOOLS;
TURBOGENERATORS
Identifiers: TOOLING; SPECIAL BORING MACHINE; POWER
GENERATION EQUIPMENT; TURBINE
02
Section Class Codes: D4410, D8250

14670 D7407176
MINIMIZING NOISE IN (MACHINE TOOL) HYDRAULIC POWER UNITS
PRICE, J.R., JR.
PRICE ENGRG. CO. INC., MILWAUKEE, WIS., USA
HYDRAUL. AND PNEUM. (USA) VOL.27, NO.5 108-10 MAY 1974
Coden: HYDPAZ
Descriptors: MACHINE TOOLS; HYDRAULIC POWER TRANSMISSION
SYSTEMS; ENVIRONMENTAL ENGINEERING; NOISE ABATEMENT
Identifiers: ISOLATION MOUNTINGS; INSULATED HCUSING; NOISE
LEVEL; MACHINE TOOL POWER UNIT
02
Section Class Codes: D4400, D5590, D7810

12313 D7404819
DESIGN OF CLOSED-LOOP PRELOADED TRANSMISSIONS (FOR MILLING
MACHINES)
GIDASPOV, I.A.; SHEININ, B.S.
STANKI AND INSTRUM. (USSR) NO.7 5-6 1973 Coden:
STIN44
Trans of: MACH. AND TOOL. (GB) VOL.44, NO.7 9-12 1973
Coden: MCTOAD
(5 Refs)
Descriptors: MILLING MACHINE TOOLS; MECHANICAL POWER
TRANSMISSION EQUIPMENT; DRIVES
Identifiers: DESIGN; MACHINE TOOL SERVO DRIVES; MILLING
MACHINES; CLOSED LOOP PRELOADED TRANSMISSIONS
02
Section Class Codes: D4410, D5550

11773 D7404279
NEW HYDRAULIC DRIVES FOR CIRCULAR-TABLE SURFACE GRINDERS
EMEL'YANOV, A.E.
VESTN. MASHINOSTR. (USSR) NO.8 25-6 1973 Coden:
VMASAV
Trans of: RUSS. ENG. J. (GB) VOL.53, NO.8 24-5 1973
Coden: RENJAG3
Descriptors: GRINDING MACHINE TOOLS; DRIVES; FLUID POWER
TRANSMISSION EQUIPMENT
Identifiers: HYDRAULIC DRIVES; CIRCULAR TABLE SURFACE
GRINDERS
02
Section Class Codes: D4410, D5550

APPENDIX VI.3 (Cont'd)

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 51 of 63) User4289 6sep77

8500 D7401006
DIRECT MEASUREMENT IN METAL CUTTING OPERATIONS
TAKEYAMA, H.; SEKIGUCHI, H.; TAKADA, K.
WERNSTATT AND BETR. (GERMANY) VOL.106, NO.9 709-14
SEPT. 1973
Descriptors: CUTTING TOOLS; MEASUREMENT
Identifiers: METAL CUTTING; MEASUREMENT; CUTTING POWER;
CHATTER VIBRATIONS; ADAPTIVE CONTROL; TOOL WEAR
02
Section Class Codes: D4410, D2420
Language: GERMAN

8479 D7400985
MEASURING CUTTING PROCESS POWER CHARACTERISTICS BY
MAIN-MOTOR CURRENT
PIKOVSKII, YU.D.; BERMDH, M.M.; GOZMAN, YA.B.; RYBKIN, I.M.
SPANNI AND INSTRUM. (USSR) VOL.44, NO.4 16-18 1973
Codon: STINA4
Trans of: MACH. AND TOOL. (GB) VOL.44, NO.4 25-8 1973
Codon: MCTOAD
(2 Refs)
Descriptors: CUTTING; ELECTRIC VARIABLES MEASUREMENT
Identifiers: MEASURING CUTTING PROCESS POWER CHARACTERISTICS
; ANALYTICAL; EXPERIMENTAL RESEARCHES; ADAPTIVE CONTROL SYSTEM
; LATHE TYPE MACHINE TOOLS; MAIN MOTOR CURRENT
02
Section Class Codes: D4410, D2290

8280 D7400786
THEORETICAL ANALYSIS FOR A DAMPING RATIO OF A JOINTED
CANTILEVER
MASUOKA, M.; ITO, Y.; YOSHIDA, K.
TOKYO INST. TECHNOL., JAPAN
BELL. JSME (JAPAN) VOL.16, NO.99 1421-32 SEPT. 1973
Codon: BJSEAB
(14 Refs)
Descriptors: BEAMS; DAMPING; SLIP
Identifiers: THEORETICAL ANALYSIS; DAMPING RATIO; JOINTED
CANTILEVER; MICROSCOPIC SLIP; ENERGY DISSIPATION; MACHINE TOOLS
02
Section Class Codes: D3220

7841 D7400347
ANALYSIS OF THE CONNECTIONS BETWEEN CUTTING POWER AND WEAR
AT ADAPTIVE CONTROL
MICHELETTI, G.F.
POLYTECH., TURIN, ITALY
WERNSTATT AND BETR. (GERMANY) VOL.106, NO.9 637-41
SEPT. 1973
(14 Refs)

Descriptors: WEAR; MACHINE TOOL CONTROL; MACHINE TOOLS
Identifiers: WEAR; ADAPTIVE CONTROL; TOOLS; TOOL POWERS;
CUTTING POWER; FEED POWER
02
Section Class Codes: D4410
Language: GERMAN

7838 D7400344
DECELERATIVE CUTTING OF 6061-T9 ALUMINUM. 65-35 BRASS. AND
TPE COPPER WITH CONSTANT IMPACT ENERGY
PLECK, M.H.; VON TURKOVICH, B.F.
UNIV. ILLINOIS, URBANA-CHAMPAIGN, USA
TRANS. ASME SER. E (USA) VOL.95, NO.3 904-12 AUG. 1973
Codon: JEFIAB
(20 Refs)
Descriptors: CUTTING; ALUMINIUM; BRASS; COPPER
Identifiers: CONSTANT IMPACT ENERGY; CHIP FORMATION PROCESS;
METAL CUTTING; EXPERIMENTAL STANDPOINT; ALUMINIUM; BRASS;
COPPER
02
Section Class Codes: D4410

7827 D7400333
MORE MUSCLE FOR ABRASIVE-BELT (GRINDING) MACHINING
FEINBERG, B.
MANUF. ENG. AND MANAGE. (USA) VOL.71, NO.4 47-9 OCT.
1973 Codon: MFEMAL
Descriptors: GRINDING MACHINE TOOLS
Identifiers: HIGH ENERGY GRINDING; BELT GRINDING MACHINES;
COATED ABRASIVES
02
Section Class Codes: D4410

7814 D7400320
OPTIMAL SELECTION OF MACHINING RATE VARIABLES BY GEOMETRIC
PROGRAMMING (UNIT COST MODEL EXAMPLE CN TURNING)
PETROPOULOS, P.G.
RES. CENTRE NAT. DEFENSE, ATHENS, GREECE
INT. J. PROD. RES. (GB) VOL.11, NO.4 305-14 OCT. 1973
Codon: IJPRB8
(18 Refs)
Descriptors: MACHINING; TURNING (LATHEWORK)
Identifiers: MACHINING; CUTTING SPEED; FEED RATE; METAL
CUTTING; OPTIMIZATION; TURNING; CUTTING POWER; SURFACE
ROUGHNESS; UNIT COST MODEL
02
Section Class Codes: D4410

APPENDIX VI.3 (Cont'd)

DIALOG File 14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 58 of 63) User 4289 6sep77

7750 07400262
POWER PRESS GIVES TOP MILEAGE (FOR SHEET METAL WORKING)
ENGINEERING (GB) VOL.213, NO.11 791 NOV. 1973 Coden:
ENG2A2
Description: PRESSES; SHEET METAL WORKING
Identifiers: POWER PRESS; SINGLE DIE; COMBINED BLANKING;
FORGING; SHALLOW DRAWING
02

Section Class Codes: D4350

4144 07304144
DYNAMIC CHARACTERISTICS OF THE INDEXING TRANSMISSION OF A
GEAR-HOBBER
VELIKOVSKI, A.L.
STAMP AND INSTRUM. (USSR) VOL.44, NO.2 5-6 1973
Codon: STPA4
Trans. of: MACH. AND TOOL. (GB) VOL.44, NO.2 9-11 1973
Codon: MCIQAD
(5 Refs)

Description: HOBGING MACHINE TOOLS; GEARS; MECHANICAL POWER
TRANSMISSION EQUIPMENT; DYNAMICS; MACHINE TOOL COMPONENTS
Identifiers: DYNAMIC; INDEXING TRANSMISSION; TORSIONAL
VIBRATION; AMPLITUDE PHASE FREQUENCY; GEAR HOBBER
02

Section Class Codes: D4410, D3730, D3220, D5550

2075 07302075
HYDRAULICS (DRIVES) FOR MACHINE TOOLS
LAI, I.
SCI. SOC. MECH. ENGRS
PNEUMATICS-HYDRAULICS 72 221-8 1973
11 24-28 OCT. 1972 GYOR, HUNGARY
SCI. SOC. MECH. ENGRS. BUDAPEST, HUNGARY
Description: MACHINE TOOLS; DRIVES; HYDRAULIC POWER
TRANSMISSION SYSTEMS
Identifiers: HYDRAULIC DRIVES; NUMERICALLY CONTROLLED
MACHINE TOOLS; SPINDLE DRIVE; FEED SYSTEMS
06

Section Class Codes: D4400, D5590
Language: GERMAN

2073 07302073
SUPPLEMENTARY AUTOMATION OF MACHINE TOOLS BY PNEUMATICS
GULIAS, I.
SCI. SOC. MECH. ENGRS
PNEUMATICS-HYDRAULICS 72 115-24 1973
1 24-28 OCT. 1972 GYOR, HUNGARY
SCI. SOC. MECH. ENGRS. BUDAPEST, HUNGARY
Description: MACHINE TOOLS; FLUID POWER TRANSMISSION
EQUIPMENT

Identifiers: PNEUMATICS; SUPPLEMENTARY AUTOMATION; MACHINE
TOOLS; MECHANICAL DEVICES; PRODUCTIVITY
06
Section Class Codes: D4400, D5550
Language: GERMAN

2063 07302063
HYDRAULIC UNITS AND SYSTEMS FOR MACHINE TOOLS
LUGOSI, L.
SCI. SOC. MECH. ENGRS
7TH MACHINE TOOL CONGRESS L1/1-5 1972
1 9-14 OCT. 1972 BUDAPEST, HUNGARY
OMKOK-TECHNOLOGY BUDAPEST, HUNGARY
Description: MACHINE TOOLS; HYDRAULIC MOTORS; NUMERICAL
CONTROL; HYDRAULIC POWER TRANSMISSION SYSTEMS
Identifiers: MACHINE TOOLS; HYDRAULIC EQUIPMENT; NUMERICAL
CONTROL; HYDRAULIC STEP MOTOR; PRESSURE CONTROLLED PUMP
06
Section Class Codes: D4400, D5500
Language: GERMAN

693 07300693
OSHA FACTORS IN MACHINE TOOL (AND PORTABLE HAND TOOL) DESIGN
(ASME PAPER NO. 73-DE-10)
WAGNER, R.W.
ROCKWELL MFG. CO., PITTSBURGH, PA., USA
ASME
DESIGN ENGINEERING CONFERENCE AND SHOW 73-DE-10/SPP.
1973
9-12 APRIL 1973 PHILADELPHIA, PA., USA
ASME NEW YORK, USA
(5 Refs)
Description: MACHINE TOOLS; PRODUCT DESIGN; MACHINE GUARDS;
SAFETY; HAND TOOLS
Identifiers: MACHINE TOOL DESIGN; OCCUPATIONAL HEALTH AND
SAFETY ADMINISTRATION; PORTABLE HAND HELD POWER TOOLS; GUARDS;
MECHANICAL SAFETY DEVICES
06
Section Class Codes: D1340, D4400, D1190, D4700

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Print 12/5/1-34

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item

1 of 34) User4289 6sep77

59523 D7706772
ELECTROSTATIC SPRAYING OF WATER-BASED COATINGS
BRACHMAN, J.
FRANKFURT-AM-MAIN, GERMANY VOL.16. NO.12 370-1
DEC. 1976 Coden: HEFOA4
Descriptors: MECHANICAL HANDLING; STORAGE
Identifiers: RATIONALIZATION; STORAGE; BULKY GOODS;
FURNITURE; PACKING; CONVEYING; FACTORIES
02
Section Class Codes: D6790
Language: GERMAN

52688 D7607425
ON TOW IN SWITZERLAND (INDUCTIVELY CONTROLLED TRACTOR TRAIN
SYSTEM FOR HANDLING FURNITURE IN WAREHOUSE)
MATER. HANDL. NEWS (GB) NO.227 88-9. 91, 93 OCT. 1976
Coden: MAHNA4
Descriptors: SURFACE HANDLING EQUIPMENT; WAREHOUSING
Identifiers: SAFETY; INDUCTIVELY CONTROLLED TRACTOR TRAIN
SYSTEM; HANDLING; FURNITURE; WAREHOUSE
02
Section Class Codes: D6750, D6790

VI. 3 - 13

50793 D7605530
MFI (FURNITURE CASH-AND-CARRY CONCERN) INTRODUCES EEDFORC
WAREHOUSING SYSTEM
THORNE, V.
FREIGHT MANAGE. (GB) VOL.10. NO.116 50. 52. 55 SEPT.
1976 Coden: FRMGBH
Descriptors: WAREHOUSING
Identifiers: PALLETS; DISTRIBUTION; CONTAINER; MFI;
WAREHOUSING SYSTEM; FURNITURE CASH AND CARRY
02
Section Class Codes: D6790

55957 D7703206
INTEGRATED FORMING SYSTEM MAKES DRAWER BODIES FOR LESS
PRECIS. MET. (USA) VOL.34. NO.11 51 NOV. 1976 Coden:
PCMB3G
Descriptors: OFFICE MACHINES AND EQUIPMENT; FILING EQUIPMENT
; AUTOMATION; PRODUCTION COSTS; FORMING EQUIPMENT; TRANSFER
LINES
Identifiers: INTEGRATED FORMING SYSTEM; DRAWER BODIES; ROLL
FORMING; WIPE FORMING; COST; METAL DESKS; FILING CABINETS;
OFFICE FURNITURE; FULLY AUTOMATIC DRAWER PRODUCTION LINE
02
Section Class Codes: D9300, D1360, D4350

55858 D7703107
RATIONALIZATION OF CONVEYING- AND STORAGE-PROCESSES FOR

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VI.3-14

DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 8 of 34) User4289 6sep77 1171

48303 07603130
ERGONOMIC EVALUATION OF WORK STRESS IN THE FURNITURE INDUSTRY
BIELSKI, J.; WOLOWICKI, J.; ZEYLAND, A.
DEPT. OF HYGIENE AND WORK SAFETY, AGRICULTURAL UNIV., POZNAN, POLAND
APPL. ERGONOMICS (GB) VOL.7, NO.2 89-91 JUNE 1976
Codon: AERG8W
(13 Refs)
Descriptons: INDUSTRIES; ERGONOMICS; PHYSIOLOGICAL
ERGONOMICS; WORKING CONDITIONS
Identifiers: ERGONOMIC EVALUATION; WORK STRESS; FURNITURE INDUSTRY; PSYCHOLOGICAL STRESS; WORK ENVIRONMENT; WORK ORGANIZATION; ENERGY EXPENDITURE; NOISE LEVELS; LIGHTING; HORIZONTAL BELT SANDING MACHINE; TILTING ARBOR SAW
02
Section Class Codes: D8790, D1320

44284 07606575
THE INFLUENCE OF WORK-PIECES AND THEIR CLAMPING ON NOISE ARISING FROM THE EDGE-CUTTING OF WOODWORKING MATERIALS
ECKERT, U.
IND. - ANZ. (GERMANY) VOL.98, NO.24 394-5 24 MARCH 1976 Codon: IANZAQ
(3 Refs)
Descriptons: CUTTING; ACOUSTIC NOISE; WOOD PROCESSING
Identifiers: WORKPIECE; EDGE CUTTING; CLAMPING; NOISE; WOODWORKING MATERIALS; FURNITURE INDUSTRY
02
Section Class Codes: D4410, D3220, D8740
Language: GERMAN

39807 07602098
PRIZE EXAMPLES OF THE DESIGN OF CASTINGS
DROSCHA, H.
IND. - ANZ. (GERMANY) VOL.97, NO.98 2091-2 15 DEC. 1975 Codon: IANZAQ
Descriptons: CASTINGS; PRODUCTION DESIGN
Identifiers: DESIGN; CASTINGS; AUTOMOBILE SPRING BRACKET; AUTOMATIC HIGH VOLTAGE COUPLER; ELECTRIC MOTOR COACHES; BUILDING ELEMENT; SCHOOL FURNITURE; BRAKE DISC
02
Section Class Codes: D4340, D1340
Language: GERMAN

AUG. 1975 Codon: FOHBAN
Descriptons: INDUSTRIAL TRUCKS; AUTOMATIC CONTROL; WAREHOUSING
Identifiers: FURNITURE; AUTOMATICALLY OPERATED TRANSPORTATION SYSTEM; INDUCTIVELY CONTROLLED TOWING UNITS; SIX STOREYS; WAREHOUSING; MANUFACTURING DEPARTMENT; DESPATCH DEPARTMENT
02
Section Class Codes: D6750, D6790
Language: GERMAN

36448 07506273
ECONOMIC MANUFACTURE OF GLASS-FIBRE REINFORCED SYNTHETIC RESIN CASTINGS FOR ASSEMBLED PARTS
BUTZ, J.
MASCHINENMARKT (GERMANY) VOL.81, NO.64 1193-4 12 AUG. 1975 Codon: MAMKAK
(2 Refs)
Descriptons: REINFORCED PLASTICS; PRODUCTION DEVELOPMENT
Identifiers: GLASS FIBRE REINFORCED SYNTHETIC RESIN CASTINGS; ECONOMIC MANUFACTURE; ASSEMBLED PARTS; CORROSION RESISTANCE; STRENGTH; IMPACT RESISTANCES; PAINT FINISHES; AUTOMOBILE; FURNITURE; ELECTRICAL; SPORTS EQUIPMENT; INDUSTRIES
02
Section Class Codes: D1340
Language: GERMAN

33977 07503802
A NEW DESIGN ELEMENT FOR MODERN KITCHENS (FORMING ELEMENT DEVELOPED FROM RESOPAL LAMINATED PLASTIC SHEET)
GRIESDORN, A.
BROWN BOVERI AND CO., BENSHEIM-AUERBACH, GERMANY
BBC NACHR. (GERMANY) VOL.57, NO.5-6 381-3 1975 Codon: BBCNAZ
Descriptons: DOMESTIC APPLIANCES; BENDING; PLASTICS; COMPOSITE MATERIALS
Identifiers: DESIGN ELEMENT; MODERN KITCHENS; FURNITURE MAKING; FORMING; RESOPAL LAMINATED PLASTIC SHEET; BENDING RADII; CONTINUOUS SHEATHING OF EDGES
02
Section Class Codes: D9500
Language: GERMAN

36950 07506775
SWITZERLAND' EUROPE'S LARGEST PLANT USING DRIVERLESS TOWING UNITS
LEMPART, P.
FOERDERN AND HEBEN (GERMANY) VOL.25, NO.11 1098-101

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33324 D7503154
METAL FURNITURE MAKER SELECTS AUTO-TYPE PLATING
MET. PROG. (USA) VOL.107, NO.5 89 MAY 1975 Coden:
MEPOA7
Descriptors: NICKEL ALLOYS; CHROMIUM; DOMESTIC APPLIANCES;
PLATING; FINISHING PROCESSES
Identifiers: NICKEL CHROMIUM; TUBULAR FURNITURE LEGS;
PROGRAMMED HOIST PLATING SYSTEM; QUALITY; RELIABILITY; COSTS
02
Section Class Codes: D9500, D4640

28836 D7506201
CAN A TURNTABLE SOLVE YOUR HANDLING PROBLEM?
RUDD, T.
WATER, HANDL. NEWS (GB) NO.208 51-5 MARCH 1975
Codon: MAHNA4
Descriptors: MECHANICAL HANDLING EQUIPMENT
Identifiers: TEXTILE PRODUCTION; PAINT SPRAYING; FURNITURE
MANUFACTURE; PAPER PRODUCTION; INDUSTRIAL TURNABLES;
MATERIALS HANDLING
02
Section Class Codes: D6770

19513 D7404507
PRODUCTION OF PRECISION (PLASTIC) MOULDS BY METAL
CASTING-ECONOMIC ALTERNATIVE TO MACHINING
NILL, D.
TECHNICAST MOULDS LTD., BERKHAMSTED, ENGLAND
EUR. PLAST. NEWS (GB) VOL.1, NO.3 48-51 JULY 1974
Descriptors: PLASTICS INDUSTRY; MOULDS; CASTING
Identifiers: PRECISION MOULDS; METAL CASTING; PLASTICS
INDUSTRY; FURNITURE; AUTOMOTIVE INDUSTRY; BUMPERS; OVER RIDERS
02
Section Class Codes: D8720, D4340

19211 D7404205
INTERNAL CLEANING OF BUILDINGS
BASO, G.
IND.-ANZ. (GERMANY) VOL.96, NO.58 1341-4 12 JULY 1974
Descriptors: CLEANING
Identifiers: INTERNAL CLEANING; BUILDINGS; RATIONALIZATION;
COSTS; FLOORINGS; FURNITURE; OPTIMUM ORGANIZATION; MACHINES;
POLISHING
02
Section Class Codes: D4610
Language: GERMAN

PLASTICS IN THE CONSTRUCTION INDUSTRY
SCHWABE, B.A.
ICP, DARMSTADT, GERMANY
POLYM. NEWS (GB) VOL.1, NO. 11-12 8-10 1973
Descriptors: POLYMERS; CONSTRUCTION INDUSTRY
Identifiers: SYNTHETICS; CONSTRUCTION INDUSTRY; FURNITURE;
POLYMER; PROCESSING INDUSTRY; UNDERGROUND; SURFACE; PVC; GLASS
FIBRE REINFORCED; POLYESTER RESIN; FOAMS
02
Section Class Codes: D8400

17790 D7402784
PLATING DIECAST DCOR FURNITURE
DIE CAST. AND MET. WOULDING (GB) VOL.6, NO.4 13-14
JUNE-JULY 1974 Codon: DIMMAH
Descriptors: FASTENERS; CASTINGS; ELECTROPLATING
Identifiers: DIECAST; DOOR FURNITURE; ELECTROPLATING;
COPPER/NICKEL/CHROME; ZINC BASE LOCKS; BARREL PLATING UNIT;
RANDOM SELECTION PROGRAMME CONTROL; BRASS; RACK PLANT
02
Section Class Codes: D4340, D4640

17177 D7402171
INTRODUCTION OF A RADICALLY NEW PRODUCT (DIE CASTING OF
GARDEN FURNITURE ITEMS)
BARKER, A.J.
MACH. AND PROD. ENG. (GB) VOL.124, NO.3213 791-3 26
JUNE 1974 Codon: MPREAU
Descriptors: DIE CASTING; PRODUCTION DEVELOPMENT
Identifiers: GARDEN FURNITURE ITEMS; COFFEE TABLE; CHAIR;
CIRCULAR TABLE; DIE CASTING; DESIGN; PRODUCTION; MARKETING;
TABLE TOP DIE
02
Section Class Codes: D4340, D1340

16211 D7401205
PROCESSING OF REFUSE INTO BUILDING MATERIAL
IND.-ANZ. (GERMANY) VOL.96, NO.45 1020-1 31 MAY 1974
Descriptors: REFUSE DISPOSAL; MATERIALS RECOVERY; WOOD
PROCESSING; BUILDING; COMPOSITE MATERIALS TECHNOLOGY
Identifiers: BUILDING MATERIAL; REFUSE DISPOSAL; STABLE
FIBRES; WOOD SHAVINGS; COMPRESSED; LAYERED EOADS;
APPLICATIONS; FURNITURE; WALL MOULDINGS; INSULATION MATERIAL;
WASTE PROCESSING; CHIPBOARD; COMPOSITE MATERIALS
02
Section Class Codes: D7836, D8400, C4370
Language: GERMAN

18157 D7403151

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DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 22 of 34) User4289 6sep77

15623 07400617
FURNITURE-A NATURAL FOR STRUCTURAL (PLASTICS) FOAMS
METCALFE, P.J.
EUROPLAST. MON. (GB) VOL.47, NO.4 58, 60 APRIL 1974
Descriptors: PLASTICS INDUSTRY; INDUSTRIES; POLYMERS
Identifiers: STRUCTURAL FOAMS; FURNITURE; PLASTICS
02
Section Class Codes: D8790

15003 07407509
DISPATCH (CONVEYOR) SYSTEM IS KEY TO NEW FURNITURE INDUSTRY
SYSTEM
WATER. HANDL. ENG. (USA) VOL.29, NO.3 63-5 MARCH 1974
Codon: RHENA4
Descriptors: INDUSTRIES; DISTRIBUTION; TRANSFER LINES
Identifiers: FURNITURE INDUSTRY; CLOSED LOOP HANDLING SYSTEM
; DISPATCH SYSTEM
02
Section Class Codes: D8790, D6720

12841 07405337
TECHNOLOGIES FOR RAPID BONDING WITH THERMOPLASTIC HOT-MELT
ADHESIVES
R ISLAND, K.
ZENTRALINST. SCHWEISSTECH., HALLE, GERMANY
FEINGERAETETECHNIK (GERMANY) VOL.23, NO.1 40 JAN. 1974
Codon: FGRTA3
(5 Refs)
Descriptors: ADHESIVES; PLASTICS
Identifiers: BONDING; HOT MELT ADHESIVES; THERMOPLASTICS;
PAPER; FURNITURE; PACKAGING; TEXTILE; SHOE INDUSTRIES
02
Section Class Codes: D4550
Language: GERMAN

11458 07403964
COST AND PERSONNEL SAVING BY MEANS OF PROFILING MACHINERY
WITH CONVEYOR BELTS (FOR OFFICE FURNITURE PRODUCTION)
MASCHINENMARKT (GERMANY) VOL.80, NO.3 37 8 JAN. 1974
Codon: MAMKAK
Descriptors: OFFICE MACHINES AND EQUIPMENT; WOOD PROCESSING;
CONVEYORS
Identifiers: RATIONAL PRODUCTION; OFFICE FURNITURE;
VERSATILE AUTOMATIC CUTTING MACHINES; CONVEYOR LINES
02
Section Class Codes: D9300, D8740, D6720
Language: GERMAN

10609 07403115
CHEAP AT HALF THE PRICE (DIAMOND SAWING OF REFRACTORY KILN
FURNITURE COMPONENTS)
HERBERT, S.
IND. DIAMOND REV. (GB) 48-50 FEB. 1974 Codon: INDRA9
Descriptors: REFRACTORIES; DIAMOND TOOLS; SAWING; FURNACES
Identifiers: REFRACTORY KILN; FURNITURE COMPONENTS; CUTTING;
ABRASIVE SAW; DIAMOND BLADED SAWS; MACHINING
02
Section Class Codes: D5210, D4410, D8760

10156 07402662
STRUCTURAL (PLASTIC) FOAMS BID FOR LARGE MASS PRODUCED PARTS
PROD. ENG. (USA) VOL.45, NO.1 29-31 JAN. 1974
Descriptors: PLASTICS; INJECTION MOULDING; DESIGN
Identifiers: LIGHTWEIGHT CELLULAR PLASTICS; TIGHTLY DESIGNED
; RIGID COMPONENTS; STRUCTURAL FOAMS; FURNITURE INDUSTRY;
INJECTION MOULDING
02
Section Class Codes: D1340, D4340

10103 07402609
THERMOFORMING AND HIGH-FREQUENCY WELDING IN THE FURNITURE
INDUSTRY
HOGER, A.
FA. PAUL KIEFEL GMBH AND KIEFEL-KORTING GMBH, FREILASSING.
GERMANY
KUNSTSTOFFTECHNIK (GERMANY) VOL.12, NO.12 334-6 DEC.
1973 Codon: KUNSBW
Descriptors: INDUSTRIES; WELDING
Identifiers: THERMOFORMING; FURNITURE INDUSTRY; WOODWORKING;
PROCESSING THERMOPLASTICS; COMPOSITES; HIGH FREQUENCY WELDING
02
Section Class Codes: D8790, D4510
Language: GERMAN

9458 07401964
FURNITURE MADE FROM EXPANDED PLASTICS FOR PROFESSION AND
LEISURE TIME
HEITZ, E.
KUNSTSTOFFTECHNIK (GERMANY) VOL.12, NO.12 330-3 DEC.
1973 Codon: KUNSBW
Descriptors: INDUSTRIES; DOMESTIC APPLIANCES
Identifiers: EXPANDED POLYURETHANE; FURNITURE INDUSTRY;
STRUCTURAL FOAMS
02
Section Class Codes: D8790
Language: GERMAN

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DIALOG File14: ISMEC-MECH ENGR 73-77/ISS13 (COPR. ISMEC) (Item 30 of 34) User4289 6sep77

9457 07401963
THERMOPLASTICS AND GRP AS MATERIALS FOR THE FURNITURE
INDUSTRY
BREITENBACH, J.
BAYER AG, LEVERKUSEN, GERMANY
KUNSTSTOFFTECHNIK (GERMANY) VOL.12, NO.12 325-9 DEC.
1973 Coden: KUNSBW
Descriptiors: PLASTICS; DOMESTIC APPLIANCES
Identifiers: THERMOPLASTICS; GRP; FURNITURE INDUSTRY;
PROCESSING METHODS; COSTS; PROPERTIES
02
Section Class Codes: D8790
Language: GERMAN

648 D7300648
COMPANY AND CUSTOMER ARE HAPPY (DELIVERY TIMES CUT BY NEW
MARKETING TECHNIQUE AND WAREHOUSE SYSTEM)
MATER. MANAGE. AND DISTRIB. (CANADA) VOL.18, NO.6 18-20
JUNE 1973
Descriptiors: COMPUTER APPLICATIONS; MARKETING; WAREHOUSING
Identifiers: MARKETING TECHNIQUE; WAREHOUSE SYSTEM; DELIVERY
TIMES; FURNITURE; COMPUTER
02
Section Class Codes: D1140, D6790

7720 07400226
ROYAL VISIT TO A NEW #2 MILLION FACTORY MANUFACTURING LOCKS
AND DOOR FURNITURE (ELECTROPLATING AND EFFLUENT TREATMENT
FACILITIES)
MET. FINISH. J. (GB) VOL.19, NO.226 309-13 NOV. 1973
Coden: MFJL9
Descriptiors: ELECTROPLATING; WATER PURIFICATION; FASTENERS
Identifiers: MANUFACTURING LOCKS; DOOR FURNITURE;
ELECTROPLATING DEPARTMENT; EFFLUENT TREATMENT; WATER
RECIRCULATING PLANT
02
Section Class Codes: D3750, D4640

6889 07306889
GROWTH OF FLEXIBLE AND RIGID URETHANE FOAM USAGE IN THE
FURNITURE INDUSTRY
BERNARD, D.L.
MURRAY CHEM. CO., PITTSBURGH, PA., USA
POLYM. NEWS (GB) VOL.1, NO.6-7 42-4 1972
Descriptiors: RUBBER
Identifiers: URETHANE FOAM; FURNITURE INDUSTRY
02
Section Class Codes: D9500

6888 07306888
PLASTICS IN FURNITURE (INDUSTRY US AND EUROPE SUMMARY)
WIECHTER, C.J.
CHAS. T. KAIN INC., BOSTON, MASS., USA
POLYM. NEWS (GB) VOL.1, NO.6-7 39-42 1972
Descriptiors: PLASTICS
Identifiers: FURNITURE INDUSTRY; RESINS
02
Section Class Codes: D9500

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NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

APPENDIX III

METHODOLOGY

ECONOMIC IMPACT OF ALTERNATIVE ENERGY POLICIES
IN A MACROECONOMIC MODEL OF NEW ENGLAND

A Report Done for the Department of Energy
and
The New England States

by

The Massachusetts Energy Office

Henry Lee
Director

Economic Impact of Alternative Energy Policies in a Macroeconomic Model of New England*

Introduction

A macroeconomic model to assess the impact of alternative energy scenarios for New England was created by Abbott, Sarris, and Taylor (1976) under the auspices of the Center for Energy Policy, Inc. That model calculates the composition of Gross Regional Product, employment, and energy use as well as changes in energy and product prices under alternative assumptions about the structure of the New England economy and in particular its energy supplying and consuming sectors. It is based on an Input-Output framework, often used in a development planning model, and incorporates additional relationships as necessary to insure consistent estimation of economic impacts.

That model was extensively modified to meet the needs of the Massachusetts Energy Office in its New England Energy Policy Alternative study. Modifications include:

1. Updating the base year from which the model projects energy policy impacts from 1967 to 1974, and in so doing obtaining an improved data base used by the model.
2. Disaggregation of the energy sectors to a level consistent with the Arthur D. Little (1974) historical data on energy use. Energy sectors now include electricity, nuclear, natural gas, LPG, gasoline, kerosene, distillate fuel oil, residual fuel oil, coal, and exotic energy forms.
3. Disaggregation by geographic region accomplished as follows: Separate data bases which can be used with the basic model structure have been produced for Northern New England (Maine, New Hampshire, and Vermont), Southern New England (Connecticut, Massachusetts, and Rhode Island), and New England. Running the model using each data base with appropriate modifications to the inputs will allow assessment of policy impacts on the two "sub-regions" in New England as well as on New England as an aggregate.

* The author, Philip C. Abbott, is an Assistant Professor of Economics at Northeastern University, Boston, Massachusetts. He gratefully acknowledges the research assistance provided by Nachum Bitan in preparing this report. He would also like to express appreciation to Alexander Sarris and Lance Taylor, who helped create the original version of this model and to Peter Clark of the Center for Energy Policy, Inc., who supported and encouraged the creation of the original model. Thanks are also due to Edwin Zeitz and Paul Levy, formerly of the Massachusetts Energy Office for supporting this research and providing input while the work was in progress. Elizabeth Berman, John Maglio, Susan Raskin, and Gustav Schacter also provided assistance and information.

4. Disaggregation of producing sectors, accomplished by providing a "manufacturing sub-model". That sub-model determines the consequences of aggregate model results on disaggregated manufacturing industries. Hence, model solutions are obtained using aggregated data, and that solution is used as the input "driving" the results of the sub-model.
5. Respecification of Energy Supply Equations in a manner consistent with the FEA PIES Model and allowing different users to be charged different prices for energy. Modifications have been made in several places in the model in order to incorporate this latter consideration.

With those modifications, the model is extremely useful in fulfilling the needs of the New England Energy Policy Alternatives Study. It provides a check on the energy price and quantity estimates provided by the FEA, by assuming their supply relationships and determining market equilibriums under an independent set of demand assumptions. It also determines changes in income, output, employment, and price variables as well as energy usages and costs, when the model's assumptions are modified to incorporate the effects of a particular policy. Estimates of regional price differentials as a result of alternative energy supply scenarios are characteristic of the model, and mechanisms representing demand for export of New England production are built into the model. Hence, the output of this model includes the macroeconomic variables one should be most interested in when assessing alternative strategies.

Report Contents

This report provides extensive documentation on the model structure, as modified, the data used to operate the model, and documentation for the computer programs used to obtain solutions for the three regional models. The following sections are included:

1. Model Specification - providing notation used in the model equations, the specification of the model equations, and a description of the overall model structure.
2. Model Operation - explaining how solutions to the "main model" and "manufacturing sub-model" are found.
3. Model Estimation - explaining derivations and indicating sources for the model parameters and base year data.
4. Input Format - describing how data is entered into the model program.
5. Output Format - describing the outputs provided by the model program.
6. Computer Listings and Decks - describing computer materials to be provided with this report.
7. Bibliography.

Model Specification

A macroeconomic energy model, based on the model constructed by Abbott, Sarris, and Taylor (1976), has been constructed to analyze in a relatively disaggregated fashion the consequences of various potential energy policies and scenarios which might be imposed on New England. This model utilized an input-output structure for production functions and pricing in sectors and for derived demands for primary products. Behavioral relationships are specified to determine adjustments in parameters, demand levels, and demographic variables. The same model structure will be implemented using data for New England, Northern New England, and Southern New England separately, in order to achieve some regional disaggregation.

As in all input-output models, the supply-demand balance for sector i is of the form:

$$\text{Production } i = \text{Intermediate Uses } i + \text{Final Uses } i$$

where final demand includes household consumption, capital investment, government expenditures, and net regional exports (gross exports less gross imports) of that sector's product. Similarly, for primary products:

$$\text{Production} = \text{Intermediate Uses}$$

since there is no final demand for primary products, given our sector definitions.*

The input-output structure also provides a pricing rule for producing sectors. In order to calculate cost-based prices for these sectors, their value added must be determined. The components of sector value added aside from the wage bill are fixed exogenously in this model, or are dependent on profit rates which are either assumed constant or modified by an exogenous shift-term. Supply equations for energy inputs are also incorporated. One possible general assumption behind these equations is that the aggregate price level for an energy input will be the average cost of its various sources of supply. In the case of petroleum, where U.S. and world supply prices might differ, the New England price is set at the average of these two imported prices weighted by their demand levels. For electricity, the price is value-added plus the average cost of inputs. As an alternative, constant elasticity supply equations are also allowed and the analyst must explicitly choose between these functional forms as an input to the model, for each energy form. For each of these energy inputs, the model will also allow for a direct tax on that input.

The consumption-and-investment demand equations assume that at constant per capita income and prices, per capita demand remains constant. When population rises, or when the stock of vehicles or dwellings rises for sectors 5 and 6, demand for

* In this framework, electricity behaves as much like a sector as it does like a primary product, and is usually treated as the latter in the specification which follows. Also, in order not to have to invert an input-output matrix in each iteration, it is assumed that primary products demand no sector outputs for intermediate uses. This oversimplification is not important, since these demands are small and can be included with our crude estimates of final demand.

consumption plus investment ($C_i + I_i$) rises proportionally. Of course, per capita ($C_i + I_i$) shifts if per capita income or relative prices should change.

A demographic model is used to keep track of population, vehicles, dwellings, and the labor force. These stocks determine demand levels and the unemployment rate.

Another set of equations determine how the primary product (energy input) use coefficients shift with relative price shifts. A functional form similar to that used by Nissen and Knapp (1975), Baughman and Joskow (1974), and Baughman and Zerhoot (1975) has been used in this model, since these are the primary sources of information on parameters measuring this behavior. The model also permits consideration of the effects of energy conservation, exogenous increases in electricity demand, and lags in the adjustment process.

In order to achieve further disaggregation of the producing sectors, a sub-model similar in nature to the above model has been constructed which allows calculation of results for 2-digit SIC level manufacturing industries. This sub-model assumes the results of the main model and utilizes the same analytical disaggregated level, assuming the pattern of production in the manufacturing sector either remains constant or is exogenously specified.

The variables and parameters used in this model (and in the program implementing it) are defined in Table 1. Using those definitions, the model specification is presented in Table 2.

Table 1
Notation Used in Presentation of
Model Equations and Model Program

I. Subscript Notation*

Producing Sectors - Aggregated

- i= 1 - Agriculture, Mining & Construction
2 - Manufacturing
3 - Commercial Transportation
4 - Services
5 - Residential Transportation
6 - Residential Energy Services
7 - Electricity

Producing Sectors - Disaggregated

- | | | | |
|------------------------|----------|----------------------------------|----------|
| j= 1 - Food | sic # 20 | 15 - Fabricated Metals | sic # 34 |
| 2 - Tobacco | 21 | 16 - Machinery | 35 |
| 3 - Textiles | 22 | 17 - Electrical Equipment | 36 |
| 4 - Apparel | 23 | 18 - Transportation Equipment | 37 |
| 5 - Lumber | 24 | 19 - Instruments | 38 |
| 6 - Furniture | 25 | 20 - Other Manufacturing | 39 |
| 7 - Paper | 26 | 21 - Agriculture | |
| 8 - Printing | 27 | 22 - Mining | |
| 9 - Chemical | 28 | 23 - Construction | |
| 10 - Petroleum & Coal | 29 | 24 - Commercial Transportation | |
| 11 - Rubber & Plastics | 30 | 25 - Services | |
| 12 - Leather | 31 | 26 - Residential Transportation | |
| 13 - Stone & Glass | 32 | 27 - Residential Energy Services | |
| 14 - Primary Metals | 33 | 28 - Electricity | |

Primary Products - Energy Forms and Labor

- k= 1 - Electricity
2 - Nuclear
3 - Natural Gas
4 - LPG
5 - Gasoline
6 - Kerosene
7 - Distillate
8 - Residual
9 - Coal
10 - Exotic Energy Forms (Hydro power, solar, etc.)
11 - Labor

Time

- t= 0 - Base Year
= n - nth Projected Year

*Not necessarily the "subscripts" (letters) used in the computer program, though the numbers correspond to what is used.

II. Endogenous Variables

- X_{it} - Production level (quantity expressed in value terms at constant prices) for sector i (aggregated)
- XSM_{jt} - Disaggregated production levels
- Y_{kt} - Primary product utilization levels
- P_{it} - Price level for goods from sector i (aggregated)
- PSM_{jt} - Price level for goods from sector j (disaggregated)
- PI_{kt} - Price for primary products (energy & labor)*
- CI_{it} - Final demand for product i as consumption or investment
- FSM_{jt} - Final demand ($C+I+X-M$) for disaggregated sectors
- PE_{it} - Average energy price to sector i
- N_t - Population
- T_t - Number of private vehicles
- D_t - Dwellings
- L_t - Labor force
- U_t - Unemployment rate

III. Exogenous Variables

- GEM_{it} - Final demand for product i from government use plus regional exports less regional imports
- PW_{kt} - World market price for energy
- PD_{kt} - Domestic (supply) price of energy
- YD_{kt} - Domestic energy supplies
- YI_t - Real disposable income
- TAX_{it} - Indirect tax on sector i (aggregated)
- $VTSM_{jt}$ - Indirect tax on disaggregated sectors
- $TAX_{\ell t}$ - Direct tax on energy inputs
($\ell = K+6$)

*In equations PI represents energy prices, but in the program additional information concerning units for this variable is stored in variables PS_{kt} and PN_{kt} .

- V_{it} - Profit on capital (proprietor's income) aggregated sectors
- $VCSM_{jt}$ - Profit on capital, disaggregated sectors
- W_{it} - Profit shifter (for exogenous changes in profit)
- G_t - Population growth rate for the region
- M_t - Net migration to the region
- $OTEM_t$ - Employment not accounted in model sectors
- $GNPDF_t$ - U.S. GNP deflator
- TTE_{it} - Time trend in demand for electricity (exogenous to price)
- DE_{it} - Percentage energy conservation in sector i
- $UPRF_{kit}$ - Factor adjusting energy price depending on end use ratio of price of energy k for sector i to price of energy k for the manufacturing sector

IV. Parameters

- A_{ij} - Input - Output coefficients: the requirements as intermediate inputs for the output of sector i per unit output of sector j (producing sector subscripts apply)
- ASM_{ij} - Input - Output coefficients for the disaggregated producing sectors
- B_{kit} - Primary product use coefficients: the requirement as an input for primary product k (energy or labor) per unit output of sector i
- BSM_{kit} - Primary product use coefficients for disaggregated sectors
- H_i - Constant in demand equation for sector i found by fitting demand to base year
- EI_i - Income elasticity of demand for product of sector i
- EP_i - Own price elasticity of demand for product of sector i
- $ECP_{i\ell}$ - Cross price elasticity of demand for product of sector i with respect to price of sector ℓ ($i \neq \ell$)
- AP_{ki} - Price elasticity of adjustment for energy use coefficients
- GA_{ki} - Constant in adjustment equation for energy use coefficients

LA_{ki}	- Lag term in adjustment equation for energy use coefficients
SES_k	- Supply elasticity with respect to price for energy k
VPC_t	- Vehicles per capita
DPC_t	- Dwellings per capita
LPR_t	- Labor force participation rate
RW_{it}	- Relative wage adjustment factor for sector i (= regional average wage rate/wage in sector i)
$RWSM_{it}$	- Relative wage adjustment factor for disaggregated sectors
$XSMF_j$	- Fractions of total manufacturing production occurring in sector j (disaggregated sectors)
DE_i	- Conservation in sector i
G_t	- Population growth rate

Table 2
Model Equations
Main Model - Aggregated Producing Sectors

1. Supply-Demand Balance for Producing Sectors

$$X_{it} - \sum_{l=1}^6 A_{li} X_{lt} = CI_{it} + GEM_{it} \quad (i=1, \dots, 6)$$

2. Derived Demand for Primary Products

$$Y_{kt} = \left(\sum_{i=1}^6 B_{kit} X_{it} \right) + B_{k7} Y_{7t} \quad (k=1, \dots, 11)$$

3. Producing Sector Pricing Relationships

$$P_{it} = \sum_{l=1}^6 A_{li} P_{lt} + \sum_{k=1}^{16} B_{kit} PI_{kt} \cdot (1 + TAX_{k+6,t}) \cdot UPRF_{ikt} + B_{11it} PI_{11t} / RW_{it} \\ + V_{it} W_{it} + TAX_{it} \quad (i=1, \dots, 6)$$

4. Supply Equations for Primary Products

(Two alternatives are possible, except for electricity, nuclear, exotic energy, and labor - average cost pricing and constant elasticity supply)

General Energy Supply ($k=3, \dots, 9$)

Constant supply elasticity

$$Y_{kt} = YD_{kt} \cdot (PI_{kt} / PD_{kt})^{(1/SES_k)}$$

Average Cost Pricing

$$Y_{kt} = YD_{kt} + (PW_{kt} - PD_{kt}) / (PW_{kt} - PI_{kt})$$

$$Y_{kt} = YD_{kt}, \text{ if above suggests } Y_{kt} < YD_{kt}, \text{ and } PI_{kt} = PD_{kt}$$

Electricity supply (Average Cost Pricing)

$$PI_{1t} = \left[\left(\sum_{k=2}^{10} B_{k7t} PI_{kt} \cdot UPRF_{7kt} \right) + B_{117t} PI_{71t} \cdot RW_{7t} + PI_{2t} \cdot Y_{2t} + W_{7t} \cdot V_{7t} \right] / Y_{1t}$$

Nuclear Supply

$$Y_{2t} = YD_{2t} \quad (\text{Nuclear plants run at capacity, with an exogenous price})$$

$$PI_{2t} = \overline{PI_{2t}}$$

Labor Supply

$PI_{11t} = PI_{11t}$ (Perfectly inelastic supply at a constant, exogenous wage rate; unemployment due to excess supply)

$$L_t = N_t \cdot LPR_t$$

$$U_t = 1 - Y_{11t}/L_t$$

5. Sectoral Demand Functions

$$CI_{1t} = N_t \cdot H_1 \cdot (YI_t/N_t)^{EI_1} \cdot (P_1)^{EP_1}$$

$$CI_{2t} = N_t \cdot H_2 \cdot (YI_t/N_t)^{EI_2} \cdot (P_2)^{EP_2} \cdot (P_4)^{ECP_{24}}$$

$$CI_{3t} = N_t \cdot H_3 \cdot (YI_t/N_t)^{EI_3} \cdot (P_3)^{EP_3} \cdot (P_5)^{ECP_{35}}$$

$$CI_{4t} = N_t \cdot H_4 \cdot (YI_t/N_t)^{EI_4} \cdot (P_4)^{EP_4} \cdot (P_2)^{ECP_{42}}$$

$$CI_{5t} = T_t \cdot H_5 \cdot (YI_t/N_t)^{EI_5} \cdot (P_5)^{EP_5} \cdot (P_3)^{ECP_{53}}$$

$$CI_{6t} = D_t \cdot H_6 \cdot (YI_t/N_t)^{EI_6} \cdot (P_6)^{EP_6}$$

6. Demographic Model

$$N_t = N_{t-1}(1+G_t) + M_t$$

$$T_t = N_t \cdot VPC_t$$

$$D_t = N_t \cdot DPC_t$$

7. Adjustment of Use Coefficients to Relative Price Shifts

$$PE_{it} = \left(\sum_{k=1}^{10} PI_{kt} B_{kit-i} UPRF_{kit} \right) / \left(\sum_{k=1}^{10} B_{kit-1} \right)$$

$$B_{kit} = \left[LA_{ki} B_{kit-1} + GA_{ki} \left(\frac{PI_{kt} UPRF_{kit}}{PE_{it}} \right)^{AP_{ki}} \right] \cdot (1-DE_i)$$

(for $k=2, \dots, 10; i=1, \dots, 7$)

$$B_{1it} = \left[LA_{1i} B_{1it-1} + GA_{1i} \cdot \left(\frac{PI_{1t} UPRF_{1it}}{PE_{it}} \right)^{AP_{1i}} \right] \cdot (1-DE_i) \cdot (1+TTE_{it})$$

(for $i=1, \dots, 6$)

8. Production Determination

$$XSM_{jt} = XSMF_{jt} X_{2t} \cdot (j=1, \dots, 20)$$

$$XSM_{jt} = XSMF_{jt} X_{1t} \cdot (j=21, \dots, 23)$$

$$XSM_{jt} = X_{it} \quad (j=i+21 = 24, \dots, 28)$$

9. Derived Demand for Primary Products

$$Y_{kt} = \sum_{j=1}^{28} (B_{kit}/B_{ki0}) \cdot BSM_{kj} \cdot XSM_{jt}$$

10. Implied Composition of Final Deamnds

$$FSM_{jt} = XSM_{jt} - \sum_{l=1}^{27} ASM_{jl} XSM_{lt}$$

11. Pricing of Disaggregated Sectors

$$PSM_{jt} = \sum_{l=1}^{27} ASM_{li} PSM_{lt} + \sum_{k=1}^{10} ((B_{kit})/B_{ki0}) \cdot BSM_{kj} \cdot PI_{kt} \cdot (1+TAX_{k+6,t}) \cdot UPRF_{kit} +$$

$$(B_{11it}/B_{11i0}) \cdot BSM_{1ij} \cdot PI_{1ij}/RWSM_j + VCSM_{jt} \cdot \frac{(V_{it} W_{it})}{V_{i0} W_{i0}} + VTSM_j \cdot \frac{(TAX_{it})}{TAX_{i0}}$$

(Where $j=1, \dots, 20$ with $i=2$)

($j=2, \dots, 23$ with $i=1$)

Model Operation

With the above specification, parameter estimates, and estimates of the exogenous variables, a projection of all endogenous variables can be made. A computer program has been written, debugged, and fitted to 1974 data for New England, Northern New England, and Southern New England, separately.

The program works in two modes, allowing for both "excess demand" and "equilibrium" solutions of the model. In the excess demand solutions, the prices of energy inputs (PI_k) are assumed to be exogenous, and the model determines endogenous variables according to the following procedure:

1. Quantities of energy inputs (Y_{it} 's) supplied at the assumed prices are calculated according to transformations of the equations in part 4 of Table 2.
2. The adjustments of the energy use coefficients (B_{ki} 's) are calculated for the assumed energy input prices using the equations in part 7 of Table 2.
3. With the energy use coefficients determined, energy input prices assumed, and all value added components given exogenously, sector price levels can be determined. These price levels are calculated according to part 3 of Table 2 and reflect the assumption that increased energy costs will ultimately be passed on entirely to consumers.
4. Final demands for each sector are calculated by using the demand equations given in part 5 of Table 2 to determine $C_i + I_i$ (or CI_i) from the P_i 's and then adding $G_i + E_i - M_i$ (or GEM_i) which have been given exogenously.
5. Production levels for sectors 1-6 can then be determined using the equations in part 1 above and the preceding estimates of final demand.
6. These production levels will require energy inputs according to the equations in part 2 of Table 2.
7. Excess demands for energy inputs may then be calculated from the demands determined in step 6.

The results of these several steps are printed out by the computer program as "excess demand" solutions. They provide a test of policies in which supplies or prices are determined exogenously, allowing market disequilibrium to persist.

After this calculation the model goes on to assume that prices of energy inputs can adjust to equilibrate demand and supply. In practice, the demands calculated in step 6 above are treated as supply levels for energy inputs and prices at which these supplies would be forthcoming are determined according to the supply equations in part 4 of Table 2. These prices become a new estimate for step 1 and by repetition of the above procedures, a new set of excess demands and supplies is calculated. The new supplies then can be used to calculate another estimate of energy input prices and the above steps are repeated again starting

at step 1. Iteration continues until the excess demands (or supplies) are an acceptably small percentage of demand. The structure of the model and use of well-behaved coefficients insures convergence relatively rapidly with this procedure, and an estimate of an equilibrium in which prices and supplies of energy inputs are determined endogenously will result. The result is the output of the "equilibrium" solution for a projection.

Solutions to the manufacturing submodel (in which the manufacturing sector is disaggregated to 2-digit SIC industries) are then calculated using the equations reported in parts 8, 9, 10 and 11 of Table 2 and the results of the "equilibrium solutions" from the main model. Hence, production levels and energy supply parameters are consistent between the aggregated and disaggregated results, and the disaggregated consequences of those results are determined. (Small inconsistencies in the total final demand and energy use for manufacturing in the aggregate model and the aggregated results of the disaggregated model and the aggregated results of the disaggregated model are possible, so these aggregates are also calculated to facilitate such a comparison. Since aggregate model parameters are based on the disaggregated model data, large discrepancies are unlikely).

Model Estimation

In this section, the methods followed in estimating parameters and base year data for the three regional models are outlined. The first part explains how regional input-output coefficients were obtained. Some data used to determine these coefficients, including regional product mixes, components of value added, and primary product requirements, are documented in subsequent parts of this section. Additional base year data for the three regional models (New England, Northern New England, and Southern New England) are also documented in this section, as well as explanations of data and sources used to determine demand elasticities, use coefficient adjustment parameters, and energy supply parameters.

Regional Input-Output Coefficients

The objective here is to describe the procedure followed to estimate regional input-output matrices for New England and Northern and Southern halves based on the latest complete United States input-output tables 1967. The element that complicates immensely the derivation of regional accounts is the fact that data on interregional movements of goods and services is, for the most part, nonexistent. There have been, nevertheless, some attempts to construct regional technologies from regional and interregional data. The latest one by Polenske (1974) derived 1963 state technologies for three industries: agriculture, mining and construction. However, these industries comprise a small portion of the N.E. economy and are all lumped in our sector 1. In addition, since Polenske's technologies are estimated from data more than a decade old, we decided not to use them.

In these models, for the determination of intermediate product requirements it was assumed that the technologies used in New England are the same as those used in the entire U.S. Since the latest national input-output

accounts are for 1967 (Bureau of Economic Analysis, U.S. Department of Commerce, 1974a) the model was estimated using this information and the 1974 product mixes for the New England states. The Bureau of Economic Analysis (BEA) input-output table is comprised of 87 industries. Interindustry transaction data were used for the first 79 of these industries, excluding 80A, 80B, and 81-87. These, with the exception of 84 (government industries), are mainly dummy industries. It was felt that their exclusion would not bias the results seriously since they account for a very small fraction of transactions. In particular, industry 80 is U.S. net imports and should not enter the computation of a New England input-output table; 81-83 are dummies and for the most part facilitate estimation of the U.S. table; 84-87 are final demand sectors (government industry, rest of the world industry, household industry and inventory valuation adjustment) which together account for 10% of total final demand.

The BEA classification was aggregated into either four or twenty-five industries. By adding the transactions in the submatrices (formed by multiplying the U.S. coefficients by the New England production levels and aggregating as required) and then dividing the column elements by their column totals, the regional input-output coefficients were derived.

There were three further modifications to the regional input-output coefficients exhibited in subsequent tables. Proprietor income and tax rates for the New England states were computed independently from information provided by the Federal Reserve Bank of Boston (Behrman, 1977). Labor costs and employment were obtained from data published by the Bureau of Labor Statistics (1976). These calculations and data sources used to determine value added coefficients, are documented in later parts of this section.

One additional modification was necessary in order to make the column totals add to one, in view of the independently estimated energy and labor coefficients. The energy and labor coefficients were first converted to value fractions, then each column of the interindustry intermediate requirement matrix was multiplied by an appropriate fraction so that, finally, the column totals of primary product costs plus intermediate costs plus value-added would sum to one.

Tables 3, 4, and 5 are each 19-by-6 matrices of the aggregate input-output coefficients for North, South, and total of New England, respectively. Columns 1 to 6 represent agriculture, mining, and construction; manufacturing; commercial transportation; services; residential transportation; and residential services, respectively. Rows 1 to 6 are the same categories as columns 1 to 6. Rows 7 to 17 are the ten energy inputs: electricity, nuclear, gas, LPG, gasoline, ✓ kerosene, distillate, residual, coal, and exotic. The last three rows (18-20) are wages, indirect business taxes, and capital income, respectively. Each coefficient represents the fraction of total cost in the column industry coming from the row industry or primary product.

In the Appendix, the three disaggregated input-output tables are given for the North, South, and whole of New England. Each of these is a 40-by-28 matrix; the format is also explained in the Appendix.

Table 3
1974 Total New England Aggregated
Adjusted Input-Output Coefficients*

	<u>Agri., Min.,& Construction</u>	<u>Mfg.</u>	<u>Comm. Trans.</u>	<u>Services</u>	<u>Res. Trans.</u>	<u>Res. Energy Services</u>	<u>Electricity</u>
Agri., Min.,& Construction	0.08240	0.04101	0.01619	0.02047	0.0	0.0	0.0
Manufacturing	0.38725	0.42935	0.03206	0.06523	0.0	0.0	0.0
Comm. Trans.	0.03008	0.01796	0.06264	0.00532	0.0	0.0	0.0
Services	0.17292	0.09968	0.9234	0.15657	0.0	0.0	0.0
Res. Trans.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Res. Energy Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	0.0	0.01059	0.0	0.01399	0.0	0.47660	0.0
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.00023	0.00215	0.0	0.00366	0.0	0.14970	0.07631
LPG	0.0	0.0	0.0	0.0	0.0	0.00720	0.0
Gas	0.00037	0.0	0.17610	0.00051	1.00000	0.0	0.0
Kerosene	0.0	0.0	0.0	0.0	0.0	0.01733	0.0
Distillate	0.00006	0.00296	0.02494	0.00704	0.0	0.34630	0.06620
Residual	0.0	0.00183	0.0	0.00320	0.0	0.0	2.93400
Coal	0.0	0.00012	0.0	0.00001	0.0	0.00027	0.30540
Exotic	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wages	0.20150	0.26420	0.30200	0.27910	0.0	0.0	0.0
Taxes	0.00709	0.01436	0.05067	0.10910	0.0	0.0	0.0
Prop. Income	0.11810	0.11580	0.24306	0.33580	0.0	0.0	0.0

* Input-Output Coefficients are value fraction spent on indicated inputs per unit output.
Rows represent inputs and columns represent outputs.

Table 4
1974 Southern Region Aggregated
Adjusted Input-Output Coefficients*

	<u>Agr., Min., & Construction</u>	<u>Mfg.</u>	<u>Comm. Trans.</u>	<u>Services</u>	<u>Res. Trans.</u>	<u>Res. Energy Services</u>	<u>Electricity</u>
Agr., Min., & Construction	0.06264	0.03762	0.01820	0.02226	0.0	0.0	0.0
Manufacturing	0.41590	0.43913	0.03603	0.06900	0.0	0.0	0.0
Comm. Trans.	0.03152	0.01735	0.07039	0.00565	0.0	0.0	0.0
Services	0.18128	0.10209	0.10376	0.16453	0.0	0.0	0.0
Res. Trans.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Res. Energy Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	0.0	0.00948	0.0	0.01351	0.0	0.45970	0.0
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.00010	0.00230	0.0	0.00394	0.0	0.17910	0.07161
LPG	0.0	0.0	0.0	0.0	0.0	0.00488	0.0
Gas	0.00022	0.0	0.16150	0.00046	1.00000	0.0	0.0
Kerosene	0.0	0.0	0.0	0.0	0.0	0.00836	0.0
Distillate	0.0	0.00160	0.02270	0.00627	0.0	0.34570	0.05958
Residual	0.0	0.00133	0.0	0.00337	0.0	0.0	2.93200
Coal	0.0	0.00009	0.0	0.00001	0.0	0.00027	0.15180
Exotic	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wages	0.20020	0.26350	0.30760	0.27600	0.0	0.0	0.0
Taxes	0.00534	0.01400	0.04982	0.10670	0.0	0.0	0.0
Prop. Income	0.10280	0.11150	0.23000	0.32830	0.0	0.0	0.0

* Input-Output Coefficients are value fraction spent on indicated inputs per unit output. Rows represent inputs and columns represent outputs.

Table 5
1974 Northern Region Aggregated
Adjusted Input-Output Coefficients*

	<u>Agr., Min., & Construction</u>	<u>Mfg.</u>	<u>Comm. Trans.</u>	<u>Services</u>	<u>Res. Trans.</u>	<u>Res. Energy Services</u>	<u>Electricity</u>
Agr., Min., & Construction	0.14391	0.05749	0.00532	0.00963	0.0	0.0	0.0
Manufacturing	0.28718	0.37376	0.01053	0.03810	0.0	0.0	0.0
Comm. Trans.	0.02482	0.02082	0.02057	0.00299	0.0	0.0	0.0
Services	0.14219	0.08603	0.03032	0.09584	0.0	0.0	0.0
Res. Trans.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Res. Energy Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity	0.0	0.01730	0.0	0.01738	0.0	0.54360	0.0
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.00076	0.00124	0.0	0.00168	0.0	0.03318	0.12520
LPG	0.0	0.0	0.0	0.0	0.0	0.01637	0.0
Gas	0.00095	0.0	0.25530	0.00088	0.99980	0.0	0.0
Kerosene	0.0	0.0	0.0	0.0	0.0	0.05282	0.0
Distillate	0.00030	0.01110	0.03695	0.01257	0.0	0.34900	0.13530
Residual	0.0	0.00478	0.0	0.00322	0.0	0.0	2.93000
Coal	0.0	0.00030	0.0	0.00001	0.0	0.00313	1.91800
Exotic	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wages	0.20690	0.26890	0.27160	0.30170	0.0	0.0	0.0
Taxes	0.01409	0.01648	0.05526	0.12620	0.0	0.0	0.0
Prop. Income	0.17890	0.14180	0.31416	0.38980	0.0	0.0	0.0

* Input-Output Coefficients are value fraction spent on indicated inputs per unit output.
Rows represent inputs and columns represent outputs.

New England Product Mix

Total production (sales, services rendered) for 1972 were obtained for most of the industries included in Standard Industry Classification (SIC) codes for each of the six states in the New England Region.

The sources used were:

- a) Census of Manufacturing (Area Statistics), 1972.
- b) Census of Construction (Area Statistics), 1972 .
- c) Census of Agriculture (Area Statistics), 1964 and 1969.
- d) Statistical Abstract of the U.S., 1976.
- e) Census of Selected Services, 1972.
- f) State Farm Income, July 1976.
- g) E. Behlmar, New England's gross product, 1955-1975, Federal Reserve Bank of Boston, 1977.

To convert the SIC production levels to correspond to the BEA classifications, we used the conversion table in the Survey of Current Business (U.S. Dept. of Commerce, 1974b). In those cases where we could not use the conversion table, either due to lack of detailed SIC census data, or because a three-digit SIC sector was partially allocated to several BEA sectors, we used the following allocation methods:

1. For BEA industries #6 and 9, the total production was taken from the Statistical Abstract of the United States, 1972. It was arbitrarily decided that 95% of the total would be allocated to BEA industry #6, and 5% to #9.
2. For BEA industries #13, 65, 66, 67, 68, 69, 70, 71, the production levels were derived by taking the appropriate New England value-added term (from the New England Gross Product) and dividing by the appropriate value-added coefficient for the U.S. (from the U.S. Input-Output tables).
3. To derive BEA industry #77's production level, the total wages for that industry were divided by the employment compensation coefficient.

The 1972 production levels for each of the BEA industries are presented in Table 9. State production levels are reported in Table 10. These data have been used to compute the regional Input-Output tables. The SIC classification production data for 1972 are presented in Table II.

To update the product mix to the models base year of 1974, the production indicators (New England Economic Indicators, Feb. 1975, and Feb. 1973) and the GNP implicit price deflator (Survey of Current Business, Dec. 1975) were used. In those industries where production indicators were not available (i.e., Agriculture and fisheries services, mining, commercial transportation, and commercial services) we used the employment data for 1972 and 1974 from County Business Patterns to arrive at the base year production levels. The results are reported in Table 12. The total 1974 agricultural production figure is the sum of the agriculture, forestry, and fishery services of Table 13 added to the productions reported in Table 14 (State Farm Statistics, July 1976).

Table 9
New England Product Mix
By Region For 1972
(in \$ millions)

BEA Industry No.	Northern Region	Southern Region	Total N.E.
1.	467.2	243.8	711.0
2.	204.7	173.0	377.7
3.	104.4	489.6	594.0
4.	46.9	222.1	269.0
5.	--	--	--
6.	3.3	4.4	7.7
7.	--	--	--
8.	--	--	--
9.	62.7	84.6	147.3
10.	--	--	--
11.	1157.5	6178.3	7335.8
12.	345.7	1845.4	2191.1
13.	121.8	2586.2	2708.0
14.	915.2	2675.5	3590.7
15.	--	87.0	87.0
16.	238.7	847.3	1086.0
17.	71.8	461.4	533.2
18.	166.3	1373.7	1540.0
19.	6.7	235.4	242.1
20.	345.9	166.4	512.3
21.	115.5	56.8	172.3
22.	104.7	261.9	366.6
23.	16.7	129.5	146.2
24.	1095.8	949.4	2045.2
25.	39.7	441.0	480.7
26.	226.0	1782.6	2008.6
27.	83.5	455.8	539.3
28.	--	558.7	558.7
29.	--	874.2	874.2
30.	--	88.2	88.2
31. 02 & 03	15.4	236.6	252.0
32.	262.4	1586.2	1848.6
33.	189.4	296.2	485.6
34.	452.2	428.8	881.0
35.	--	108.2	108.2
36.	171.9	648.2	820.1
37.	18.8	527.0	545.8
38.	73.6	1646.0	1719.6
39.	--	181.7	181.7
40.	131.4	579.4	710.8
41.	25.4	735.6	761.0
42.	63.8	1606.2	1670.0
43.	20.9	173.1	194.0
44.	--	--	--
45.	--	125.7	125.7
46.	--	106.1	106.1

BEA Product Mix (Con't.)

BEA Industry No.	Northern Region	Southern Region	Total N.E.
47.	125.3	738.8	864.1
48.	107.7	764.4	872.1
49.	74.8	671.8	746.6
50.	18.2	237.7	255.9
51.	86.6	1063.0	1149.6
52.	10.7	138.5	149.2
53.	184.6	675.7	860.3
54.	--	266.7	266.7
55.	153.7	545.2	698.9
56.	12.7	1216.6	1229.3
57.	263.9	637.2	901.1
58.	126.9	195.3	322.2
59.	--	624.8	624.8
60.	70.4	1354.9	1425.3
61.	108.9	1170.9	1279.8
62.	112.5	772.2	884.7
63.	35.1	1196.5	1231.6
64.	63.1	1813.6	1876.7
65.	550.3	2795.5	3345.8
66.	330.8	1832.5	2163.3
67.	53.8	298.3	352.1
68. 03	27.7	178.4	206.1
69.	2525.2	14024.0	16549.2
70.	819.5	4435.7	5255.2
71.	973.2	10349.8	11323.0
72.	355.2	4624.2	4979.4
73.	236.1	2550.8	2786.9
74.	--	--	--
75.	110.5	567.6	678.1
76.	121.0	475.4	596.4
77.	982.6	6790.6	7773.2
78.	--	--	--
79.	--	--	--
80.	--	--	--
81.	--	--	--
82.	--	--	--
83.	--	--	--
84.	--	--	--
85.	--	--	--
86.	--	--	--
87.	--	--	--
88.	--	--	--
89.	--	--	--
90.	--	--	--
91.	--	--	--
92.	5962.5	34965.1	40927.6
93.	1342.3	7871.1	9213.4
94.	--	--	--
95.	--	--	--

BEA Product Mix

BEA Industry No.	Northern Region	Southern Region	Total N.E.
96.	--	--	--
97.	--	--	--
98.	--	--	--
99.	--	--	--
100.	--	--	--
101.	--	--	--
102.	9667.0	56688.0	66355.0
103.	--	--	--
104.	--	--	--

(Con't.)

Table 10
1972 Production Levels
By States By BEA Classifications
(in \$ millions)

	Conn.	Maine	Mass.	N.H.	R.I.	Vt.
1.	128.6	227.7	104.7	52.9	10.5	186.6
2.	74.8	170.9	86.4	17.7	11.8	16.1
3.	9.0	95.0	433.4	9.4	47.2	--
4.	85.2	17.8	117.1	14.3	19.8	14.8
5.	--	--	--	--	--	--
6.	1.6	1.1	2.6	0.5	.2	1.7
7.	--	--	--	--	--	--
8.	--	--	--	--	--	--
9.	31.4	20.9	49.4	9.5	3.8	32.3
10.	--	--	--	--	--	--
11.	1922.2	447.3	3636.1	484.7	620.0	225.5
12.	574.1	133.6	1086.1	144.8	185.2	67.3
13.	2156.1	64.	423.1	--	7.0	57.8
14.	555.6	492.5	1900.5	232.0	219.4	190.7
15.	87.0	--	--	--	--	--
16.	187.5	116.7	421.3	116.1	238.5	5.9
17.	122.0	71.8	274.0	--	65.4	--
18.	259.8	66.5	1001.2	86.8	112.7	13.0
19.	36.2	2.8	190.1	3.9	9.1	--
20.	34.5	184.0	127.7	91.3	4.2	70.6
21.	10.8	93.7	40.6	21.8	5.4	--
22.	89.7	10.2	172.2	31.9	--	62.6
23.	61.9	6.6	49.6	10.1	18.0	--
24.	214.3	767.8	699.6	228.0	35.5	100.
25.	109.1	16.0	296.4	18.9	35.5	4.8
26.	552.1	56.7	1081.5	103.6	149.0	65.7
27.	251.6	38.1	198.8	33.5	5.4	11.9
28.	117.7	--	378.7	--	62.3	--
29.	382.1	--	458.2	--	33.9	--
30.	11.2	--	68.6	--	8.4	--
31.	153.5	15.4	69.0	--	14.1	--
32.	414.2	81.2	980.6	143.7	191.4	37.5
33.	10.2	112.3	261.2	65.5	24.8	11.6
34.	19.1	272.7	384.9	179.5	24.8	--
35.	38.5	--	19.2	--	50.5	--
36.	218.9	39.0	412.4	67.2	16.9	65.7
37.	311.8	--	143.1	18.8	72.1	--
38.	868.6	37.0	400.4	36.6	377.0	--
39.	100.	--	61.7	--	20.0	--
40.	247.5	26.5	290.1	44.0	41.8	60.9
41.	326.9	20.0	346.5	5.4	62.2	--
42.	857.7	20.0	682.8	43.8	65.7	--
43.	63.6	20.9	106.0	--	3.5	--
44.	--	--	--	--	--	--
45.	19.7	--	106.0	--	--	--

Table 10
1972 Production Levels
By States By BEA Classifications
(in \$ millions)

	Conn.	Maine	Mass.	N.H.	R.I.	Vt.
46.	--	--	106.1	--	--	--
47.	295.5	6.2	363.1	38.5	80.2	80.6
48.	185.4	13.	495.9	89.2	83.1	5.5
49.	407.6	20.	232.8	54.8	31.4	--
50.	110.4	3.8	110.9	10.1	16.4	4.3
51.	229.9	--	833.1	54.6	--	32.0
52.	56.3	--	82.2	--	--	10.7
53.	266.0	128.0	409.7	56.6	--	--
54.	192.4	--	74.3	--	--	--
55.	218.8	--	251.6	56.6	74.8	97.1
56.	262.7	12.7	927.9	--	26.0	--
57.	172.0	79.6	388.2	87.2	77.0	97.1
58.	49.9	--	113.8	56.6	31.6	70.3
59.	63.8	--	535.7	--	25.3	--
60.	1029.1	--	325.8	--	--	70.4
61.	1029.1	66.	120.6	42.9	21.2	--
62.	269.7	7.4	449.7	84.8	52.8	20.3
63.	318.5	--	825.2	28.3	52.8	6.8
64.	409.5	12.4	727.5	33.4	676.6	17.3
65.	780.2	277.7	1798.9	148.2	216.4	124.4
66.	535.9	137.8	1177.5	126.8	119.1	66.2
67.	87.2	22.4	191.7	20.6	19.4	10.8
68.	91.8	15.6	76.9	12.1	9.7	--
69.	4285.1	1113.4	8556.4	899.3	1182.5	512.5
70.	1671.3	493.0	2469.6	217.8	294.8	108.7
71.	3899.7	211.3	5762.3	508.3	687.3	253.6
72.	374.754	140.019	765.061	129.353	111.403	85.798
73.	755.869	85.046	1644.373	101.027	150.534	50.109
75.	173.538	48.931	349.845	43.793	44.337	17.744
76.	104.123	30.300	332.218	53.708	39.107	37.094
77.	1923.7	393.9	4326.3	367.0	540.6	221.7

Table 11
New England
Product Mix By SIC Categories - 1972
(in \$ millions)

	<u>Northern Region</u>	<u>Southern Region</u>	<u>New England</u>
Agr. Mining & Const.	2099.9	9124.3	11224.2
Agriculture	530.7	1011.6	1542.3
Mining	66.0	89.0	155.0
Construction	1503.2	8023.7	9526.9
Total Mfg.	6453.1	34501.2	40954.3
SIC # (20)	915.2	2675.5	3590.7
(22)	372.2	1619.9	1992.1
(23)	173.0	1609.1	1782.1
(24)	461.4	223.2	684.6
(25)	121.4	391.4	512.8
(26)	1135.5	1390.4	2525.9
(27)	226.0	1782.6	2008.6
(28)	83.5	1976.9	2060.4
(30)	262.4	1586.2	1848.6
(31)	641.6	725.0	1366.6
(32)	171.9	756.4	928.3
(33)	92.4	2173.0	2265.4
(34)	220.6	3102.9	3323.5
(35)	444.2	4019.1	4463.3
(36)	741.8	3536.7	4278.5
(37)	179.3	3150.6	3329.9
(38)	147.6	1968.7	2116.3
(39)	63.1	1813.6	1876.7
Comm. Trans.	550.3	2795.5	3345.8
Services	6535.6	46127.3	52662.9

Table 12
New England
Product Mix By SIC Categories -1974
(in \$ millions)

	Northern Region	Southern Region	New England
Agr. Mining & Const.	\$2732.8	\$10897.6	\$13630.4
Agriculture	856.5	1138.9	1995.4
Mining	68.3	107.8	176.1
Construction	1808.0	9650.9	11458.9
Total Mfg.	\$7543.7	\$45343.4	\$52887.1
SIC # (20)	1020.0	2982.0	4002.0
(21)	0	0	0
(22)	368.9	1605.6	1974.5
(23)	170.8	1588.8	1759.6
(24)	595.3	287.9	883.2
(25)	156.6	504.9	661.5
(26)	1227.6	1503.2	2730.8
(27)	248.6	1961.1	2209.7
(28)	91.9	2174.8	2266.7
(29)	15.4	236.6	252.0
(30)	303.9	1837.3	2141.2
(31)	576.8	651.8	1228.6
(32)	221.8	975.8	1197.6
(33)	91.3	2148.0	2239.3
(34)	272.2	3828.5	4100.7
(35)	639.4	5785.2	6424.6
(36)	911.8	4347.2	5259.0
(37)	359.6	8045.6	8405.2
(38)	190.4	2539.6	2730.0
(39)	81.4	2339.5	2420.9
Comm. Trans.	528.4	2878.2	3406.6
Services	6990.3	50157.6	57147.9

Table 13
Employment - Output Ratios

	<u>"72" Output</u>	<u>"72" Employment</u>	<u>Output per Employment</u>	<u>"74" Employment</u>	<u>"74" Output</u>
Northern Region					
Agr. Services & Forestry Services	151.3	2506	.0604	2426	146.5
Mining	66.0	1281	.0515	1326	68.3
Comm. Trans.	550.3	8998	0.0612	8640	528.4
Services	6535.6	300722	0.0217	321642	6990.3
Southern Region					
Agr. Services & Forestry Services	711.7	9648	.07376	9642	711.3
Mining	89.0	2595	.0343	3144	107.8
Comm. Trans.	2795.5	43349	0.064488	44632	2878.2
Services	46127.3	1686526	0.02735	1833882	50157.6

Table 14
1974 Cash Receipts From Farming
(in 000's \$)

<u>State</u>	<u>Live Stock and Products</u>	<u>Crops</u>	<u>Total</u>
Maine	\$227,736	\$190,425	\$418,161
Mass.	105,992	87,970	193,962
N.H.	52,128	19,057	71,185
Conn.	126,618	84,029	210,647
R.I.	11,890	11,063	22,953
Vt.	203,504	17,087	220,591

Table 15
Relative Sectional Wage Factors
1974 - Aggregated Sectors

	<u>Northern Region</u>	<u>Southern Region</u>	<u>New England</u>
Agriculture, Mining & Construction	1.041	0.770	0.850
Manufacturing	0.876	0.835	0.851
Commercial Transportation	0.785	0.863	0.860
Services	1.171	1.119	1.138
Residential Transportation	1.000	1.000	1.000
Residential Energy Services	1.000	1.000	1.000
Electricity	0.520	0.520	0.520

Consumption & Investment by Sector

The consumption equations, as described in a previous section, comprise the consumption plus investment portion of final demand. There exist no recent data, neither by sector nor aggregate form, which could be used as Consumption and Investment values for either New England or for its individual states. These members were estimated using the national Input-Output Table which breaks final demand by sector into its various components. The consumption and investment values for each sector of New England could be estimated in either of two ways. One would be to compute the U.S. fractions of consumption and investment in GNP and then multiply these by GRP for each region. The other method is to compute national per capita consumption and investment in the considered sectors, and then multiply these by New England population or the subregion populations. These two give similar results; the former method was used.

The primary source for estimating income elasticities of demand as well as own and cross-price elasticities (to be used in those equations) was the detailed analysis of Houthakker and Taylor (1970). Approximations to income elasticities were obtained by weighing the various subsector elasticity estimates by their share in final demand. (This task was complicated because the BEA factors do not correspond to the expenditure categories of Houthakker and Taylor.) Some care was taken to try to preserve Engle aggregation* for the income elasticities.

Base Year Data - Residuals

Necessary for accounting consistency in the model is a set of estimates of the balance of final demand by sector, i.e., data on G+E-M or government expenditures plus exports minus imports of the region. Such estimates do not exist and, furthermore, it seems notoriously hard to build intuition as to their magnitudes. The approach used to estimate these demand flows was to treat them as residuals, using the matrix expression $G+E-M = X-AX-(C+I)$ for the base year - in other words, let the model determine these values. These G+E-M estimates appear to be the weakest parameters in the entire model. Since these exogenous estimates comprise a sizable portion of final demand (about 20%), they might have significant influence over predictions. However, in the absence of any independent data, the model itself can be used to obtain their approximate magnitudes. The difficulty this presents is that values for these parameters will be needed as exogenous driving factors for projections (inputs); thus, residual estimation will not be possible - yet without residual estimation, projection of these values seems extremely difficult. Given this problem, the most sensible procedure would be to increase these values at the projected rate of growth of GNP.

* Engle aggregation refers to the fact that the sum of income elasticities for various expenditure categories multiplied by their budget shares sums to one. Analytically: $\sum_i f_i n_i = 1$ where : f_i - budget share of i'th category
 n_i - budget elasticity of i'th category

Since the model outlined in the previous sections is of a consistency type, its base year solution should accurately reproduce the data with which it was estimated. In other words, the equilibrium solutions for a 1974 "projection" of production levels, prices, etc., should be nearly identical to the actual historical figures if exogenous variables are set at their 1974 levels. In particular, if the fit were perfect, the sector prices that result should all equal unity. And, the model should be able to predict GRP from both value-added in production, and from final demand. However, due to this model's neglect of government industries and of interregional capital and income transfers, this consistency is not completely achieved. Nevertheless, the consistency framework was helpful in identifying anomalies in the data base.

Relative Sectoral Wage Factors

The relative sectoral wage factor is the ratio of the average wage for the region to the average sectoral wage in that region*. The average sectoral wage was derived from employment and wage data for each sector. The relative wage factors for the aggregated sectors of Northern, Southern, and total New England are presented in Table 15. The relative wage factors for the disaggregated sectors are shown in Table 16.

The wage and employment data for the New England states for industrial SIC codes were taken from the Quarterly Reports issued by the Bureau of Labor Statistics (1974). The agricultural wage and employment data were taken from Agricultural Statistics (1974). These figures are shown in Table 17.

All of the above data were used to generate the labor-use coefficients (employment coefficients) which are reported in the Input-Output Tables on pages 15, 16, and 17, and in the Appendix.

* As entered in the program, listed in the Tables, and described above, this relative wage is the inverse of what commonly might be termed a relative wage.

Table 16
1974 Relative Sectoral Wage Factors
Disaggregated Sectors

	<u>Northern</u>	<u>Southern</u>	<u>Total New England</u>
SIC #(20)	0.9096	0.9045	0.8784
(21)	0.0	0.0	0.0
(22)	1.0606	1.0303	0.9973
(23)	1.3175	1.3733	1.3731
(24)	0.9613	1.0744	0.9946
(25)	1.1191	1.0563	1.0099
(26)	0.6699	0.7963	0.8243
(27)	0.8313	0.8380	0.8311
(28)	0.7437	0.6476	0.6443
(29)	0.8247	0.5414	0.5214
(30)	1.0189	0.9656	0.9404
(31)	1.2508	1.3172	1.2262
(32)	0.7768	0.7828	0.7713
(33)	0.7715	0.7695	0.7706
(34)	0.7912	0.8133	0.8179
(35)	0.7361	0.7392	0.7354
(36)	0.7799	0.8368	0.8349
(37)	0.7692	0.6642	0.6585
(38)	0.8608	0.7684	0.7695
(39)	1.2039	1.1431	1.1471
Agriculture	1.4627	1.6800	1.7006
Mining	0.7710	0.7279	0.6433
Construction	0.8481	0.7327	0.6961
Comm. Trans.	0.7848	0.8595	0.8631
Services	1.1705	1.1375	1.1194
Residential Trans.	1.0	1.0	1.0
Residential Energy Serv.	1.0	1.0	1.0
Electricity	0.520	0.520	0.520

Table 17
1974 Wages & Employment
By Regions & By Producing Sectors

	Wages (in \$ millions)			Employment (in man-years)		
	Northern Region	Southern Region	Total New England	Northern Region	Southern Region	Total New England
Total Agr. Mining & Const.	565.5	2181.5	2747.0	79278	194502	273780
Agriculture	179.2	160.9	340.1	35300	31700	67000
Mining	13.6	23.2	36.8	1412	1729	3141
Construction	372.7	1997.4	2370.1	42566	161073	203639
Total Mfg.	2028.8	11946.5	13975.3	239314	1155176	1394490
Food (20)	121.6	464.0	585.6	14896	47217	62113
Textile (22)	107.6	448.8	556.4	15368	51853	67221
Apparel (23)	44.8	372.8	417.6	7949	59301	67250
Lumber (24)	179.1	57.8	236.9	23185	6660	29845
Furniture (25)	36.9	144.3	181.2	5561	16882	22443
Paper (26)	304.9	457.2	762.1	27505	43659	71164
Printing (27)	97.7	673.9	771.6	10937	64886	75823
Chemicals (28)	25.5	476.1	501.6	2554	35539	38093
Petroleum & Refining (29)	2.2	34.7	36.9	249	2093	2342
Rubber & Plastics (30)	98.9	553.1	652.0	13570	60256	73826
Leather (31)	177.3	199.9	377.2	29864	28397	58261
Stone & Clay (32)	53.2	279.7	332.9	5565	24991	30556
Primary Metal (33)	38.8	552.5	592.3	4031	49411	53442
Fabricated Metal (34)	68.9	1246.0	1314.9	7341	118061	125402
Machinery Metal (35)	213.1	1787.7	2000.8	21125	152309	173434
Electrical Equip (36)	327.1	1600.4	1927.5	34355	154789	189144
Transportation (37)	80.6	1294.7	1375.3	8349	98764	107113
Instruments (38)	28.0	752.0	780.0	3246	67034	70280
Other (39)	22.6	549.9	572.5	3664	73074	76738
Commercial Trans. Services	143.5 2109.0	885.3 13843.2	1028.8 15952.2	15166 332444	88519 1795254	103685 2127698

Indirect Business Taxes and Property (Capital) Income

The New England's Gross Product (1977) and the Indirect Business Taxes Supplement, documented and provided by Elizabeth Berman of the Federal Reserve Bank of Boston, were invaluable in determining the components and totals of value-added for New England industries. To determine property income, we simply subtracted wages and indirect business taxes from each sector's total value-added. For agriculture, indirect taxes were determined by multiplying the total production in New England agriculture by the appropriate U.S. coefficient. Having thus found wages, indirect business taxes, and property income for each sector, we divided each item by that sector's total product to yield the value-added coefficients. Data on property (capital) income, indirect business taxes, and total value-added are presented in Table 18.

Demographic Data

Data on several demographic variables for New England and its Northern and Southern regions are required by the three models. The figures for population, labor force, employment, dwellings, and vehicles were obtained from Statistical Abstract of the U.S. (1974) and are presented in Table 19. The labor force participation rate, dwellings per capita, vehicles per capita, and the employment not included in the producing sectors (such as government employment) have been derived from that data.

Table 18. Components of Value-Added for New England Industries - 1974 (in \$ millions)

PRODUCING SECTORS	Property (Capital)		Income		Indirect Business Taxes		Total Value - Added	
	Northern Region	Southern Region	Total N. E.	Total N. E.	Northern Region	Southern Region	Northern Region	Total N.E.
Agri. Mining & Const.	489.0	1120.3	1609.3	96.7	38.5	58.2	1093	4453
Agriculture	204.7	85.4	290.1	39.8	20.1	19.7	404	670
Mining	31.6	61.6	93.2	11.0	3.8	7.2	49	141
Construction	252.7	973.3	1226.0	45.9	14.6	31.3	640	3642
Total Mfg.	1069.8	5054.6	6124.4	759.2	124.3	634.9	3223	20859
Food	58.6	218.5	277.1	200.3	41.8	158.5	222	1063
Textiles	57.9	238.8	296.7	17.9	3.5	14.4	169	871
Apparel	14.2	106.1	120.3	9.1	1.0	8.1	60	547
Lumber	190.9	65.5	256.4	10.7	8.0	2.7	378	504
Furniture	13.0	39.8	52.8	5.0	1.1	3.9	51	239
Paper	214.7	332.9	547.6	36.3	14.4	21.9	534	1346
Printing	40.5	259.0	299.5	21.9	2.8	19.1	141	1093
Chemicals	21.1	374.9	396.0	27.4	1.4	26.0	48	925
Petroleum & Refin.	2.24	61.25	63.49	7.56	46.9	7.1	5	108
Rubber & Plastics	41.1	125.4	166.5	94.5	16.0	78.5	156	913
Leather	65.8	75.5	141.3	10.5	4.9	5.6	248	529
Stone & clay, glass	24.8	126.1	150.9	12.2	2.0	10.2	80	496
Primary metals	33.5	464.1	497.6	26.1	1.7	24.4	74	1116
Fabricating metals	28.8	502.2	531.0	44.1	2.3	41.8	100	1890
Machinery	84.1	652.8	736.9	62.3	6.8	55.5	304	2800
Electrical Equipt.	126.1	621.6	747.7	57.8	9.8	48.0	463	2733
Transp. Equipt.	34.6	336.5	371.1	75.6	4.8	70.8	120	1822
Instruments	10.2	270.1	280.3	21.7	0.8	20.9	39	1082
Other	7.7	183.6	191.3	18.2	0.7	17.5	31	782
Comm. Trans.	166.0	662.1	828.0	172.6	29.2	143.4	338.7	2029
Services	2724.5	16467.2	19191.7	6232.1	882.5	5349.6	5716	41376

Table 19
1974 Demographic Data
By State

	Population (000's)	Gross Product (Millions)	Labor Force (000's)	Employment (000's)	Dwelling (000's)	Vehicles (000's)
Maine	1,049	5,122	437.3	408.0	354.6	637
N.H.	808	4,295	366.7	353.5	269.1	490
Vt.	468	2,412	200.0	186.0	156.3	285
<u>N. Region</u>	2,325	11,829	1004.0	947.5	780.0	1412
Conn.	3,086	22,342	1442.6	1354.6	981.3	1991
Mass.	5,799	37,344	2638.9	2448.9	1862.3	3042
R.I.	938	5,486	428.8	397.5	302.0	568
<u>S. Region</u>	9,823	65,177	4510.3	4200.4	3150.6	5601
<u>Total N.E.</u>	12,148	77,006	5514.3	5147.9	3930.6	7013
	Wage Rate \$/hr.	Pop. Growth Rate %	Labor Force Participation	Dwelling Per Capita	Vehicles Per Capita	Increase in Annual Wage Rate % 1975 1976
Maine	3.51	1.0	.42	.34	0.61	9 9
N.H.	3.64	2.0	.45	.33	0.61	8 8
Vt.	3.78	1.0	.43	.33	0.61	8 8
<u>N. Region</u>	3.57	1.35	.44	.33	0.61	8.4 8.4
Conn.	4.42	0.3	.47	.32	0.65	8 7
Mass.	4.16	0.4	.46	.32	0.52	7 7
R.I.	3.63	0.3	.46	.32	0.61	6 8
<u>S. Region</u>	4.15	0.36	.47	.32	0.57	7.2 7.1
<u>Total N.E.</u>	4.10	0.55	.47	.32	0.58	7.4 7.4

Energy Supply Parameters

The specification of the supply equations in this model allows a choice functional form by the analyst. In the initial estimation of this model we have adopted the assumption used by the Federal Energy Administration in New England Energy Situation Alternatives for 1985 (1976). That assumption is that all energy supply functions are perfectly elastic to the New England region, with the prices of alternative energy forms determined exogenously. We have also used that source to determine the fraction of energy supplies which are imported directly from abroad. Those fractions are:

Petroleum-Residual	72%
Distillate	12%
Gasoline	9%

Many other specifications of these supply relationships are possible within the model structure.

Energy Usage

Since some manufacturing industries are not required to disclose their energy usage in the Annual Census of Manufacturers, energy data from that source is incomplete. Further, individual items of a column do not sum to the column total.

In these cases where data went undisclosed, we assumed that the 1971 ADL report adequately represented industry behavior. We then used the New England production indices to better reflect 1974 patterns - in essence, we assumed no conservation effort. After these projections of undisclosed energy usage were included, some of the column sums were either higher or lower than the reported column totals.

In the case of a column sum being larger than the reported total, we diminished the projected undisclosed energy usages by applying the following formula:

$$E_{ij}^u = \frac{X_i - \sum_{j=1}^N E_{ij}}{\sum_{j=1}^D P_{ij}^u} \cdot P_{ij}^u$$

- Where:
- E_{ij}^u = adjusted undisclosed usage of energy i in industry j.
 - X_i = total usage of energy i.
 - N = number of industries
 - E_{ij} = usage of energy i in a disclosed industry j
 - D = number of projected undisclosed industries
 - P_{ij}^u = projected undisclosed energy usage i in industry j

In the case of a column sum being lower than the reported total, we adjusted every industry usage according to its relative share of the reported total. The following formula was applied:

$$E_{ij} = \frac{X_i}{\sum_{j=1}^N P_{ij}} \cdot P_{ij}$$

Where: E_{ij} = adjusted energy usage i in industry j
 X_i = total usage of energy i
 P_{ij} = energy usage (disclosed and undisclosed) i in industry j
 N = number of industries

These procedures are implied by the assumption that: If the total energy usage projected is too low, then the census data has overstated conservation in all industries; whereas, if total energy usage is too high, conservation in the projected industries has been understated. Fortunately, only small adjustments in manufacturing energy-use data were required.

The adjusted energy use coefficients, derived as described above, are shown in Tables 20 & 21. Data for the energy use in services, residential services, and the electrical sector were provided by the Federal Energy Commission's "Strawman" energy data base. We assumed that, for the most part, the transportation sectors used gasoline as their energy source.

The Federal Highway Report (1970) furnished the amounts of gasoline purchased for highway and non-highway use. The latter is sub-divided further into Agriculture, Construction, and Commercial sector use. The relative shares of highway gasoline use between the commercial and residential sectors came from the Jack Faucett and Associates report entitled, Energy Consumption by Transportation Mode (1973). In this regard, we were required to assume that the New England distribution paralleled the U.S. distribution: 71.8% of the total highway use of gasoline is consumed by the residential transportation sector and 28.2% of the total is consumed by the commercial transportation sector.

Electricity-use figures were obtained from the Electric Utility Industry of New England, Statistical Bulletin 1974 and are presented in Tables 20 & 21. Total production of electricity is the sum of its uses.

All of the above data was then used to generate energy-use coefficients by dividing an industry's fuel use by that industry's production.

Table 20
Northern Region
1974 Energy Usage
(in trillions of btu's)
Disaggregated

SIC#	Elect.	Nuc.	N. G.	LPG	Gas	Kero.	Dist.	Resid.	Coal	Exotic
20	1.351	0	.497	0	0	0	1.948	2.456	.098	0
21	0	0	0	0	0	0	0	0	0	0
22	.957	0	.894	0	0	0	.360	1.560	.341	0
23	.066	0	0	0	0	0	.009	.008	.023	0
24	.869	0	.114	0	0	0	.742	.438	.096	0
25	.249	0	0	0	0	0	.167	.008	.011	0
26	7.404	0	.421	0	0	0	32.836	33.554	.226	0
27	.340	0	.154	0	0	0	.163	.092	1.047	0
28	.106	0	.265	0	0	0	.317	.088	.003	0
29	0	0	0	0	0	0	0	0	0	0
30	.870	0	.043	0	0	0	.608	.552	.093	0
31	.591	0	0	0	0	0	.492	.406	.048	0
32	.755	0	1.030	0	0	0	.665	1.822	.204	0
33	0	0	.108	0	0	0	0	.029	.040	0
34	.385	0	.010	0	0	0	.301	.207	.006	0
35	.829	0	.154	0	0	0	.867	.242	0	0
36	.693	0	0	0	0	0	1.407	.031	.017	0
37	.107	0	0	0	0	0	.099	0	.006	0
38	.153	0	0	0	0	0	.084	0	.006	0
39	.182	0	0	0	0	0	0	.054	.068	0
Agr.	0	0	.784	0	.785	0	.400	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0
Const.	0	0	.032	0	.108	0	0	0	0	0
Comm.										
Trans.	0	0	0	0	41.77	0	9.584	0	0	0
Serv.	10.630	0	3.550	0	1.913	0	43.060	25.958	.0775	0
Res.										
Trans.	0	0	0	0	105.309	0	0	0	0	0
Res. En.										
Ser.	20.481	0	6.370	6.575	0	10.698	75.533	0	.1439	0
<u>Aggregated</u>										
AMC	0	0	.816	0	.892	0	.400	0	0	0
Mfg.	15.907	0	3.690	0	0	0	41.065	41.547	2.334	0
Elec.	0	20.67*	1.675	0	0	0	1.810	39.2	25.664	13.02*

* These two figures represent the total electrical energy produced from these energy sources (implied efficiency of 1.0). In the computer simulation and in the output, these will be lumped together into 33.69 of "Nuclear" capacity, which is allocated to users before other electricity is generated.

Table 21
Southern Region
1974 Energy Usage
(in trillions of btu's)
Disaggregated

<u>SIC#</u>	<u>Elect.</u>	<u>Nuc.</u>	<u>N. G.</u>	<u>LPG</u>	<u>Gas</u>	<u>Kero.</u>	<u>Dist.</u>	<u>Resid.</u>	<u>Coal</u>	<u>Exotic</u>
20	2.449	0	3.075	0	0	0	2.108	2.596	0	0
21	0	0	0	0	0	0	0	0	0	0
22	3.200	0	3.485	0	0	0	2.821	6.367	.020	0
23	.783	0	.239	0	0	0	.214	.180	.041	0
24	.293	0	.103	0	0	0	.591	.426	.041	0
25	.289	0	.103	0	0	0	.441	.481	.840	0
26	4.145	0	1.555	0	0	0	6.197	15.671	1.941	0
27	1.598	0	.717	0	0	0	.712	.195	0	0
28	3.531	0	2.742	0	0	0	2.098	14.264	.612	0
29	.279	0	.069	0	0	0	.789	.286	.013	0
30	4.525	0	1.435	0	0	0	1.598	3.758	.259	0
31	.456	0	.102	0	0	0	.299	.591	.033	0
32	1.922	0	4.144	0	0	0	3.394	2.886	0	0
33	4.795	0	6.560	0	0	0	3.091	4.215	0	0
34	5.632	0	6.355	0	0	0	3.460	4.612	.375	0
35	5.136	0	3.075	0	0	0	2.147	3.091	.028	0
36	4.847	0	2.424	0	0	0	1.468	2.729	.035	0
37	4.218	0	2.153	0	0	0	1.592	4.227	.008	0
38	1.876	0	1.640	0	0	0	1.211	1.640	0	0
39	2.410	0	1.128	0	0	0	1.309	1.524	0	0
Agr.	0	0	.274	0	.276	0	1.655	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0
Const.	0	0	.165	0	.557	0	0	0	0	0
Comm.										
Trans.	0	0	0	0	143.914	0	32.049	0	0	0
Ser.	59.307	0	59.883		7.128	0	154.201	194.63	.253	0
Res.										
Trans.	0	0	0	0	362.826	0	0	0	0	0
Res. En.										
Ser.	68.549	0	136.080	7.762	0	6.706	296.125	0	.4696	0
<u>Aggregated</u>										
AMC	0	0	0.439	0	.833	0	1.655	0	0	0
Mfg.	52.384	0	41.104	0	0	0	35.538	69.739	4.2463	0
Elec.	0	37.05*	10.071	0	0	0	8.380	412.41	21.343	2.76*

* These two figures represent the total electrical energy produced from these energy sources (implied efficiency of 1.0). In the computer simulation and in the output, these will be lumped together into 39.81 of "Nuclear" capacity, which is allocated to users before other electricity is generated.

Table 22
New England
1974 Energy Usage
(in trillions of btu's)
Disaggregated

SIC#	Elect.	Nuc.	N. G.	LPG	Gas	Kero.	Dist.	Resid.	Coal	Exotic
20	3.800	0	3.572	0	0	0	4.056	5.052	.098	0
21	0	0	0	0	0	0	0	0	0	0
22	4.157	0	4.379	0	0	0	3.181	7.927	.361	0
23	.849	0	.239	0	0	0	.223	.188	.064	0
24	1.162	0	.217	0	0	0	1.333	.864	.137	0
25	.538	0	.103	0	0	0	.608	.489	.851	0
26	11.549	0	1.976	0	0	0	39.033	49.225	2.167	0
27	1.938	0	.871	0	0	0	.875	.287	1.047	0
28	3.637	0	3.007	0	0	0	2.415	14.352	.615	0
29	.279	0	.069	0	0	0	.789	.286	.013	0
30	5.395	0	1.478	0	0	0	2.206	4.310	.352	0
31	1.047	0	.102	0	0	0	.791	.997	.081	0
32	2.677	0	5.174	0	0	0	4.059	4.708	.204	0
33	4.795	0	6.668	0	0	0	3.091	4.244	.040	0
34	6.017	0	6.365	0	0	0	3.761	4.819	.381	0
35	5.965	0	3.229	0	0	0	3.014	3.333	.028	0
36	5.540	0	2.424	0	0	0	2.875	2.760	.052	0
37	4.325	0	2.153	0	0	0	1.691	4.227	.014	0
38	2.029	0	1.640	0	0	0	1.295	1.640	.006	0
39	2.592	0	1.128	0	0	0	1.309	1.578	.068	0
Agr.	0	0	1.058	0	1.061	0	2.055	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0
Const.	0	0	.197	0	.665	0	0	0	0	0
Comm.										
Trans.	0	0	0	0	185.684	0	41.633	0	0	0
Ser.	69.937	0	63.433	0	9.041	0	197.261	220.588	.3305	0
Res. Tr.	0	0	0	0	468.135	0	0	0	0	0
Res. En.										
Serv.	89.030	0	142.450	14.337	0	17.404	371.658	0	.6135	0
<u>Aggregated</u>										
AMC	0	0	1.255	0	1.725	0	2.055	0	0	0
Mfg.	68.291	0	44.794	0	0	0	76.603	111.286	6.5803	0
Elec.	0	57.72*	11.746	0	0	0	10.190	451.61	47.007	15.78*

* These two figures represent the total electrical energy produced from these energy sources (implied efficiency of 1.0). In the computer simulation and in the output, these will be lumped together into 73.50 of "Nuclear" capacity, which is allocated to users before other electricity is generated.

Energy Prices

The assembly of a detailed list of 1974 New England energy prices to various energy-users was largely successful. The sources and procedures used in obtaining the prices given in Tables 23 & 24 are as follows:

1. Natural Gas Prices - Prices were obtained from the 1974 Rate Book published by the American Gas Association, and from the National Coal Association's Coal Facts, 1974-75.
2. Liquid Petroleum Gas - Prices were taken from Wholesale Price Index, 1974.
3. Gasoline - The cost of gasoline to the manufacturing sector was obtained from the 1974 Rate Book. The 1974 Oilgram Price Services (Platt's) reports prices of gasoline at the service station, excluding taxes.
4. Kerosene, Distillate, Residual - The Platt's Oilgram also gave the costs of kerosene, distillate, and residual to the end-user.
5. Coal - The costs of coal and natural gas to the electrical sector were obtained from Coal Facts, 1974-75 (National Coal Association); but this report only provides 1972 prices. To update the 1972 prices we used the Commodity Prices Index as reported in the Survey of Current Business (Dec. 1973 & 1975). Those prices were assumed to reflect the cost to the manufacturing sector.
6. Electricity, Nuclear - The 1975 Electric Utility Industry of New England, Statistical Bulletin was the primary source for electrical rates charged to different users; this source also provided measurements of the nuclear production of electricity. The appropriate nuclear price was provided by the public information department of Boston Edison.

Table 23
New England
1974 Energy Prices
By End User
(\$ per million of btu's)

	<u>Elect.</u>	<u>Nuclear</u>	<u>N.G.</u>	<u>LPG</u>	<u>Gas</u>	<u>Kero.</u>	<u>Dist.</u>	<u>Resid.</u>	<u>Coal</u>	<u>Exotic</u>
AMC	\$8.204	0	2.54	1.0995	2.91	2.18	2.04	0.868	.96	0
Mfg.	8.204	0	2.54	1.0995	2.91	2.18	2.04	0.868	.96	0
Comm. Trans.	0	0	0	0	3.23	2.18	2.04	0	0	0
Ser.	11.43	0	3.3	1.0995	3.23	2.18	2.04	0.868	.96	0
Res. T.	0	0	0	0	3.23	0	2.04	0	0	0
Res. S.	11.72	0	2.3	1.0995	0	2.18	2.04	0	.96	0
Elect.	0	.62	.68	0	2.91	2.18	2.04	0.868	.96	0

Table 24
New England
1974 Energy Prices
By End User
(in common units)

	<u>Units</u>	<u>Manuf.</u>	<u>Comm. Tr.</u>	<u>Comm. Serv.</u>	<u>Res. Tr.</u>	<u>Res. Serv.</u>	<u>Elec.</u>
Electricity	¢/KWH	2.800	--	3.640	--	3.920	--
Nuclear	¢/KWH	--	--	--	--	--	0.212
Nat. Gas	\$/10 ³ ft ³	2.620	--	3.377	--	2.353	0.696
LPG	\$/bbl	4.410	--	--	--	--	--
Gasoline	¢/gal	36.410	40.40	--	40.40	--	--
Kerosene	¢/gal	29.400	--	--	--	--	--
Dist. #2	¢/gal	28.300	--	28.300	--	28.300	--
Resid. #6	¢/gal	13.000	--	13.000	--	--	13.000
Coal	\$/s.t.	25.15	--	--	--	--	25.15
Exotic	\$/s.t.	--	--	--	--	--	--

Energy Use Coefficient Adjustment Parameters

Equations allowing the derived demand for energy to vary with changes in energy prices have been incorporated in this model. Potential sources of information on the magnitude of parameters in those equations include: Nissen and Knapp (1975), Project Independence Report (1974), Baughman and Joskow (1974), Baughman and Joskow (1975), and Baughman and Zerhoot (1975). The equations used in this model are similar but not identical to those used in the above studies. Also, the data base used in the above studies was never New England (generally, equations were estimated for the U.S.). Nevertheless, the results of these studies represent the best available information on these parameters. The relevant parameter estimates are presented in Table 25.

Since the Baughman and Zerhoot (1975) study used an equation specification most closely resembling that used here, their estimates will be used, with one exception. We shall assume that the lags in adjustment are somewhat longer than those estimates imply. In sectors where parameter estimates have not been obtained no adjustment in energy use coefficients will be allowed.

Table 25
Energy Usage Substitution Elasticities*

	Baughman & Joskow, 1975		Baughman & Zerhoot, 1975		Project Independence Report, 1974	Nissen & Knapp, 1974
	<u>Short Run</u>	<u>Long Run</u>	<u>Short Run</u>	<u>Long Run</u>	<u>Long Run</u>	<u>Long Run</u>
<u>Residential & Commercial</u>						
Electricity	-0.16	-0.8	--	-0.76	-0.44	-1.00
Natural Gas	-0.11	-0.7	--	-0.55	-0.37	-0.8
Distillate	-1.79	-1.12	--	-0.39	-0.64	-0.5
<u>Industrial</u>						
Electricity	--	--	-0.28	-1.8	--	-0.33
Natural Gas	--	--	-0.16	-1.0	-1.5	-0.09
Coal	--	--	-0.25	-1.6	-0.59	-0.75
Residual	--	--	-0.28	-1.8	-0.34	-1.00

*Energy usage substitution elasticities are the per cent change in the final market share for the indicated fuel type as a result of a 1 per cent change in the price of that fuel.

**The short run in all studies is one year.

Input Format For The New England Macroeconomic Energy Model Program

There are three types of data read in by the program which projects macroeconomics and energy scenarios for New England. The first set of data is the headings for the output tables. These need not be altered unless the output routines are to be changed. Following these headings begin the two sets of numbers used by the program. These include data on a base year used to normalize the model and to estimate constants for the equations of the model, and the data on exogenous variables for years to be projected. The base year data also includes input-output coefficients and demand elasticities as well as other program parameters. In using this program one may wish to alter data in either of these two sets (e.g. alter parameters, change the base year, or input alternative exogenous scenarios).

Comment cards are included in the data to make location of a particular data card easier. The program expects to read these cards, so they cannot be removed. Data should also not be put on the comment cards, as it will be ignored.

The data is read in by the program in free formatted input procedures. Hence it is not necessary to put data in particular columns on cards. There must be a space between each entry, however, so the input procedure can recognize where one entry ends and another begins. The number of cards used to enter a number of entries does matter, however. Since each read command in the program requires at least one card (but may use more than one), there is a minimum number of cards which can be used. Wherever more than one entry is required for either a sector or a primary product for a particular variable, then a new card is required to begin each sector or primary product.

One further comment which should be made is that whenever the program reads in an exogenous variable for a set of projection scenarios, it is required to read in the base year value first. This is so that the program knows what units are used for that variable and in some cases what to normalize that variable to. In some cases reading in that entry is unnecessary, but for consistency we have required reading in that entry in all cases. Also, where prices are read in for energy inputs, all prices for the same energy input must be in the same units. Hence, when the world market price and initial equilibrium estimate price for oil are read in for petroleum, the prices must have the same units in each case, though choice of what units that should be doesn't matter.

A listing of the comment cards in the data deck is presented in Table 26; these use the variable abbreviations of Table 1. The number of cards (minimum), the entries per card, and the units in which each entry must be expressed are given in parentheses after each card.

Table 26. Input Format for the New England Macro-Economic Energy Model

Base Year Production Levels

X_{i0} , $i=1-6$ (1x6, in millions of current \$)

Y_{k0} , $k=1-11$ (1x11, in trillions of BTU's for energy and
millions of man-years for labor)

Consumption and Investment by Sectors (Base-year)

CI_{i0} , $i=1-6$ (1x6, in millions of current \$)

Stocks and Income (Base-Year)

N_0, T_0, D_0, L_0, YI_0 (1x5, in millions of people, vehicles,
dwellings, workers, and current \$)

Demand Elasticities:

Income

EI_i , $i=1-6$ (1x6)

Own Price

EP_i , $i=1-6$ (1x6)

Cross Price

ECP_{ij} , $i=24,35,42,53$ (1x4)

Use Coefficient Adjustment Parameters:

Price Elasticities

AP_{ki} , $k=1-10, i=1-7$ (7x10, sectors are rows)

Lag Terms

LA_{ki} , $k=1-10, i=1-7$ (7x10, sectors are rows)

Aggregate I-0 Table Intermediate Requirements

A_{ij} , $i=1-6, j=1-6$ (6x6, in value fractions inputs are rows)

Aggregate Value-Added Property Income (Base-Year)

V_{i0} , $i=1-7$ (1x7, in value fractions)

Aggregate Use Coefficients - Energy and Labor (Base-Year)

B_{ki0} , $k=1-11$, $i=1-7$ (7x11, in trillion BTU's per million current \$ for energy, and in million man-years per million current \$ for labor; rows are sectors)

Energy Input Prices Used for Normalization (Base-Year)

PI_{k0} , $k=1-11$ (1x11, in million current \$ per trillion BTU's for energy, and in million current \$ per million man-years for labor)

Years to be Projected

n , t_0 (1x2, number of projections to be done, base-year)

Intervals Between Projected Years

- internal- (1xn, difference in years between years to be projected and previous year projected or base-year)

These two sections will not be printed in the output list of inputs.

Conservation Terms

DE_i , $i=1-7$ (7x(n+1), in fractions of base year energy use)

This is the first case where a base-year value and a value for each projection case are entered. Whenever (n+1) is indicated, there should be an entry for the base year and each projection case.

Functional Indicators for the Supply Equation Parameters

l_k , $k=1-11$ (1x11, enter 0 or 1; 0 indicates average cost pricing is to be used for that energy form, 1 indicates that constant elasticity supply is to be used for that energy form)

Supply Elasticities - Inverted

SES_k , $k=1-11$ (1x11)

Domestic Energy Prices

PD_{kt} , $k=1-10$ (10x(n+1), in common units)

World Energy Prices

PW_{kt} , $k=1-10$ (10x(n+1), in common units same as above)

Initial Equilibrium Price Estimates

PI_{kt} , $k=1-10$ (10x(n+1), in common units same as above)

Domestic Energy Supplies

YD_{kt} , $k=1-10$ (10x(n+1), in trillions of BTU's)

GNP Deflator

$GNPDF_t$ (1x(n+1), 1974 value is 1.0)

Exogenous Driving Factors:

Wages

PI_{11t} (1x(n+1), in current \$ per hour)

Disposable Incomes

YI_t (1x(n+1), in million current \$)

Pop'n Growth Rates

G_t (1x(n+1), in fraction of total population per year)

Demand Levels

GEM_{it} (6x(n+1), in million current \$)

Net Migration

M_t (1x(n+1), in fractions of total population per year)

Other Empl.

$OTEM_t$ (1x(n+1), in million man-years)

Taxes

TAX_{ik} , $i=1-17$ (17x(n+1), in fractions of value)

Labor Force Part. Rate

LPR_t (1x(n+1), in workers per capita)

Vehicles per Capita

$$VPC_t \quad (1 \times (n+1))$$

Dwellings per Capita

$$DPC_t \quad (1 \times (n+1))$$

Capital Income Adj. Terms

$$W_{it}, i=1-7 \quad (7 \times (n+1), \text{ indicates } (V_{it} + TAX_{it}) / (CV_{i0} + TAX_{i0}))$$

Agg. Rel. Sectoral Wage Factors

$$RW_{it}, i=1-7 \quad (7 \times (n+1), \text{ indicates } wage_i / PI_{11})$$

Exogenous Electricity by Time Trend

$$TTE_{it}, i=1-6 \quad (6 \times (n+1), \text{ in fractions of electricity by use})$$

Factors Adjusting Diff. Prices to Diff. Users

$$UPRF_{ikt}, i=1,3-6, k=1-10 \quad (10 \times 5, \text{ indicates } \frac{PI_k \text{ to sector } i}{PI_k \text{ to sector } 2}, \text{ rows are energy forms})$$

Inputs to Manufacturing Sub-Model:

Production Fractions

$$SXM_{F_j}, j=1-23 \quad (1 \times 23)$$

Disagg. I-0 Table of Intermediate Requirements

$$ASM_{j1}, j=1-27, 1-1-27 \quad (27 \times 27) \text{ in value fractions, rows are inputs}$$

Disagg. Value-Added Property Income

$$VCSM_j, j=1-28 \quad (1 \times 28, \text{ in value fractions})$$

Disagg. Value-Added Taxes

$$VTSM_{j0}, j=1-28 \quad (1 \times 28, \text{ in value fractions})$$

Disagg. Use Coeffs. - Energy and Labor

$$BSM_{kj0}, k=1-10, j=1-28 \quad (28 \times 11, \text{ same units as aggregated sectors, rows are disaggregated sectors})$$

Disagg. Relative Sector Wage Factors

$$RWSM_{j0}, j=1-27 \quad (1 \times 27, \text{ as a fraction})$$

Output Format for the New England Macroeconomic Energy Model

The computer program which implements the mathematical model also controls the printing of the output. After each run, the program provides several types of output:

- (A) information concerning the program itself,
- (B) a listing of the inputs provided by the program-user,
- (C) eleven summary tables of economic activity and energy-use for the base-year, as directly implied by the input data,
- (D) the aggregate and disaggregate input-output tables of the first simulation's equilibrium solution (i.e., A of GEM = $X-AX-CI$, see part 1 of Table 2), and the transformed input-output matrix which is of primary importance in determining prices (i.e., $(I-A^t)^{-1}$ for $P=(I-A^t)^{-1} V$ from $P=A^tP+V$, see part 3 of Table 2),
- (E) the excess demand solutions for the first simulation run (eleven summary tables of economic activity and energy-use), and
- (F) the equilibrium solutions for the first simulation run (eleven summary tables of economic activity and energy use).

The information referred to in part (A) might not appear if the program has been previously read-in and stored for use. The listing mentioned in part (B) appears in the output in free format; this output may not appear, at first, to be equivalent to the entries listed in the input deck. Nevertheless, this section should be carefully scrutinized to insure that no errors were made in the input section. This portion of the output also provides a complete, concise, attached record of the projection conditions. The eleven summary tables referred to in parts (C), (E) and (F) will appear for the base year and each solution of each projection year. These output tables are illustrated in Tables 27-37, but instead of containing sample values, these tables explain the units of measurement. The eleven tables which are mentioned in part (C) are simple manipulations of the input data, and are not formed through use of the model's projection mechanisms. The data of parts (D), (E) and (F) are presented for each year which was to be projected.

Table 27
First Output Table

Entitled: Stocks, Unemployment, CPI

1 Column: Total

13 Rows:

1	POPULATION	Millions of People
2	VEHICLES	Millions of Vehicles
3	DWELLINGS	Millions of Dwellings
4	LBR FORCE	Millions of Workers
5	UNEMPLOYMENT	Fraction (x100 will give %)
6	CPI	1974=1
7	GNP DEFL	1974=1
8	CPINE/CPI	1974=1
9	GRP REAL	Millions of 1974 Dollars
10	GRP NCM	Millions of Current Dollars
11	LBR PART R	Workers/Population
12	VEH PC	Vehicles/Population
13	DWELL PC	Dwellings/Population

Table 28
Second Output Table

Entitled: Sector Activity and Prices Constant (1974) Dollars

7 Columns: 1-AGRI & MINE, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS
 6-RES EN SERV, 7-TOTAL

13 Rows:

1	PRICE	1974=1, deflated by GNP Deflator Index
2	PRODUCT Q*	Millions of 1974 dollars worth at 1974 prices
3	PRODUCT V	Millions of 1974 dollars worth at current prices
4	FIN DEM Q	Millions of 1974 dollars worth at 1974 prices
5	FIN DEM V	Millions of 1974 dollars worth at current prices
6	C+I Q	Millions of 1974 dollars worth at 1974 prices
7	C+I V	Millions of 1974 dollars worth at current prices
8	G+E-M Q	Millions of 1974 dollars worth at 1974 prices
9	G+E-M V	Millions of 1974 dollars worth at 1974 prices
10	VAL ADDED	Millions of 1974 dollars worth at 1974 prices
11	VA CAP	Millions of 1974 dollars worth at 1974 prices
12	VA TAX	Millions of 1974 dollars worth at 1974 prices
13	VA LER	Millions of 1974 dollars worth at 1974 prices

* Q indicates a quantity and V a value figure

Table 29
Third Output Table

Entitled: Sector Activity and Prices - Current Dollars

7 Columns: 1-AGRI & MINE, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS,
6-RES EN SER, 7-TOTAL

13 Rows:

1	PRICE	1974=1 Index
2	PRODUCT Q*	Millions of 1974 dollars worth at 1974 prices
3	PRODUCR V	Millions of current dollars worth at current prices
4	FIN DEM Q	Millions of 1974 dollars worth at 1974 prices
5	FIN DEM V	Millions of current dollars worth at current prices
6	C+I Q	Millions of 1974 dollars worth at 1974 prices
7	C+I V	Millions of current dollars worth at current prices
8	G+E-M Q	Millions of 1974 dollars worth at 1974 prices
9	G+E-M V	Millions of current dollars worth at current prices
10	VAL ADDED	Millions of current dollars worth at current prices
11	VA CAP	Millions of current dollars worth at current prices
12	VA TAX	Millions of current dollars worth at current prices
13	VA LBR	Millions of current dollars worth at current prices

* Q indicates a quantity and V a value digure

Table 30
Fourth Output Table

Entitled: 1974 Primary Product Uses and Costs - Constant 1974 Dollars

12 Column: 1-ELECTRIC, 2-NUCLEAR, 3-NATURAL GAS, 4-LPG, 5-GASOLINE,
6-KEROSENE, 7-DISTILLATE, 8-RESIDUAL, 9-COAL, 10-EXOTIC,
11-TOTAL EN, 12-LABOR

24 Rows:

1	DEMAND	Q*	Trillion Btu's for Energy	Million Man Years
2	EX DEM	Q	Trillion Btu's for Energy	Million Man Years
3	SUPPLY	Q	Trillion Btu's for Energy	Million Man Years
4	IMPORT	Q	Trillion Btu's for Energy	Million Man Years
5	DEMAND	V*	Trillion of 1974 dollars worth at current prices	
6	EX DEM	V	Trillion of 1974 dollars worth at current prices	
7	IMPORT	V	Trillion of 1974 dollars worth at current prices	
8	PRICE SUP		Common Units - See below	
9	PRICE CON		Common Units - See below	
10	TAX RATE		Fraction	
11	SQ** AG&MIN		Trillion Btu's for Energy	Million Man Years
12	SQ MAN		Trillion Btu's for Energy	Million Man Years
13	SQ COM TR		Trillion Btu's for Energy	Million Man Years
14	SQ SER		Trillion Btu's for Energy	Million Man Years
15	SQ RES TR		Trillion Btu's for Energy	Million Man Years
16	SQ RES ES		Trillion Btu's for Energy	Million Man Years
17	SQ ELEC		Trillion Btu's for Energy	Million Man Years
18	C*** AG&MIN		Millions of 1974 dollars worth at current prices	
19	C MAN		Millions of 1974 dollars worth at current prices	
20	C COM TR		Millions of 1974 dollars worth at current prices	
21	C SER		Millions of 1974 dollars worth at current prices	
22	C RES TR		Millions of 1974 dollars worth at current prices	
23	C RES ES		Millions of 1974 dollars worth at current prices	
24	C ELEC		Millions of 1974 dollars worth at current prices	

* Q indicates a quantity and V a value figure

** SQ is quantity in the listed sector of energy or labor used at estimated production levels

*** C is cost in the listed sector for the energy or labor input

Table 30 (Con't)
Fourth Output Table

Electric	-	¢ per Kilowatt-hour
Nuclear	-	¢ per Kilowatt-hour
Natural Gas	-	\$ per thousand cubic feet
LPG	-	\$ per barrel
Gasoline	-	¢ per gallon
Kerosene	-	¢ per gallon
Distillate	-	¢ per gallon
Residual	-	¢ per gallon
Coal	-	\$ per short ton
Exotic	-	\$ per Btu
Labor	-	\$ per hour

Table 31
Fifth Output Table

Entitled: 1974 Primary Product Uses and Costs - Current Dollars

12 Column: 1-ELECTRIC, 2-NUCLEAR, 3-NATURAL GAS, 4-LPG, 5-GASOLINE,
6-KEROSENE, 7-DISTILLATE, 8-RESIDUAL, 9-COAL, 10-EXOTIC
11-TOTAL EN, 12-LABOR

24 Rows:

1	DEMAND Q*	Trillion Btu's for Energy	Million Man Years
2	EX DEM Q	Trillion Btu's for Energy	Million Man Years
3	SUPPLY Q	Trillion Btu's for Energy	Million Man Years
4	IMPORT Q	Trillion Btu's for Energy	Million Man Years
5	DEMAND V*	Trillion of current dollars worth at current prices	
6	EX DEM V	Trillion of current dollars worth at current prices	
7	IMPORT V	Trillion of current dollars worth at current prices	
8	PRICE SUP	Common Units - See Table 30	
9	PRICE CON	Common Units - See Table 30	
10	TAX RATE	Fraction	
11	SQ** AG&MIN	Trillion Btu's for Energy	Million Man Years
12	SQ MAN	Trillion Btu's for Energy	Million Man Years
13	SQ COM TR	Trillion Btu's for Energy	Million Man Years
14	SQ SER	Trillion Btu's for Energy	Million Man Years
15	SQ RES TR	Trillion Btu's for Energy	Million Man Years
16	SQ RES ES	Trillion Btu's for Energy	Million Man Years
17	SQ ELEC	Trillion Btu's for Energy	Million Man Years
18	C*** AG&MIN	Millions of current dollars worth at current prices	
19	C MAN	Millions of current dollars worth at current prices	
20	C COM TR	Millions of current dollars worth at current prices	
21	C SER	Millions of current dollars worth at current prices	
22	C RES TR	Millions of current dollars worth at current prices	
23	C RES ES	Millions of current dollars worth at current prices	
24	C ELEC	Millions of current dollars worth at current prices	

* Q indicates a quantity and V a value figure

** SQ is quantity in the listed sector of energy or labor used at estimated
production level

*** C is cost in the listed sector for the energy or labor input

Table 32
Sixth Output Table

Entitled: 1974 Interindustry Flows

6 Columns: 1-AGRI&MINE, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS
6-RES EN SER j=1

6 Rows:

i=	1	AGRI&MINE	Output of sector i in millions of 1974 dollars at 1974 prices going to sector j as an intermediate input
	2	MANUFAC	
	3	COM TRANS	
	4	SERVICE	
	5	RES TRANS	
	6	RES EN SER	

Table 33
Seventh Output Table

Entitled: 1974 Primary Product User Coefficients

7 Columns: 1-AGRI&MINE, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS,
6-RES EN SER, 7-ELECTRIC

10 Rows:

1	ELECTRIC	Million Btu's per \$1 of output of sector i
2	NUCLEAR	Million Btu's per \$1 of output of sector i
3	NAT GAS	Million Btu's per \$1 of output of sector i
4	LPG	Million Btu's per \$1 of output of sector i
5	GASOLINE	Million Btu's per \$1 of output of sector i
6	KEROSENE	Million Btu's per \$1 of output of sector i
7	DISTILLATE	Million Btu's per \$1 of output of sector i
8	RESIDUAL	Million Btu's per \$1 of output of sector i
9	COAL	Million Btu's per \$1 of output of sector i
10	EXOTIC	Million Btu's per \$1 of output of sector i
11	LABOR	Man years per \$1 of output of sector i

Table 34
Eighth Output Table

Entitled: 1974 Energy Prices by Sector - Constant 1974 Dollars

7 Columns: 1-AGRI&MINE*, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS
6-RES EN SER, 7-ELECTIRC

10 Rows:

1	ELECTRIC	¢ per Kilowatt-hour
2	NUCLEAR	¢ per Kilowatt-hour
3	NAT GAS	\$ per thousand cubic feet
4	LPG	\$ per barrell
5	GASOLINE	¢ per gallon
6	KEROSENE	¢ per gallon
7	DISTILLATE	¢ per gallon
8	RESIDUAL	¢ per gallon
9	COAL	\$ per short ton
10	EXOTIC	\$ per Btu

* End-User to whom price reported is charged

Table 35
Ninth Output Table

Entitled: 1974 Energy Prices by Sector - Current Dollars

7 Columns: 1-AGRI&MINE*, 2-MANUFAC, 3-COM TRANS, 4-SERVICE, 5-RES TRANS,
6-RES EN SER, 7-ELECTRIC

10 Rows:

1	ELECTRIC	¢ per Kilowatt-hour
2	NUCLEAR	¢ per Kilowatt-hour
3	NAT GAS	\$ per thousand cubic feet
4	LPG	\$ per barrell
5	GASOLINE	¢ per gallon
6	KEROSENE	¢ per gallon
7	DISTILLATE	¢ per gallon
8	RESIDUAL	¢ per gallon
9	COAL	\$ per short ton
10	EXOTIC	\$ per Btu

* End-User to whom price reported is charged.

Table 36
Tenth Output Table

Entitled: 1974 Manufacturing Submodel Results - Constant 1974 Dollars

8 Columns: 1-FOOD, 2-TOBACCO, 3-TEXTILE, 4-APPAREL, 5-LUMBER, 6-FURNITURE, 7-PAPER, 8-PRINTING, 9-CHEMICAL, 10-PET&COAL, 11-RUBBER&PLA, 12-LEATHER, 13-STONE&GLASS, 14-PRI. METAL, 15-FAB.METAL, 16-MACHINERY, 17-ELEC. EQUIP, 18-TRANS EQP, 19-INSTRUMENT, 20-OTHER, 21-TOTAL MANUFAC, 22-AGRI, 23-MINING, 24-CONSTRUCT 25-TOTAL A-M-C

32 Rows:

1	PRICE	1974=1 deflated by GNP deflator Index
2	PRODUCT Q	Millions of 1974 dollars worth at 1974 prices
3	PRODUCT V	Millions of 1974 dollars worth at current prices
4	FIN DEM Q	Millions of 1974 dollars worth at 1974 prices
5	FIN DEM V	Millions of 1974 dollars worth at current prices
6	VAL ADDED	Millions of 1974 dollars worth at current prices
7	VA CAP	Millions of 1974 dollars worth at current prices
8	VA TAX	Millions of 1974 dollars worth at current prices
9	VA LABOR	Millions of 1974 dollars worth at current prices
10	LABOR Q	Millions of man-years
11	ELEC SQ	Trillions of Btu's
12	NUC SQ	Trillions of Btu's
13	NAT GAS SQ	Trillions of Btu's
14	PLG SQ	Trillions of Btu's
15	GAS SQ	Trillions of Btu's
16	KERO SQ	Trillions of Btu's
17	DIST SQ	Trillions of Btu's
18	RESID SQ	Trillions of Btu's
19	COAL SQ	Trillions of Btu's
20	EXOTIC SQ	Trillions of Btu's
21	TOTAL SQ	Trillions of Btu's
22	ELEC C	Millions of 1974 dollars worth at current prices
23	NUC C	Millions of 1974 dollars worth at current prices
24	NAT GAS C	Millions of 1974 dollars worth at current prices
25	LPG C	Millions of 1974 dollars worth at current prices
26	GAS C	Millions of 1974 dollars worth at current prices
27	KERO C	Millions of 1974 dollars worth at current prices
28	DIST C	Millions of 1974 dollars worth at current prices
29	RESID C	Millions of 1974 dollars worth at current prices
30	COAL C	Millions of 1974 dollars worth at current prices
31	EXOTIC C	Millions of 1974 dollars worth at current prices
32	TOTAL C	Millions of 1974 dollars worth at current prices

* 25 Sectors or Totals are reported on this and subsequent pages of this table.
Units are the same for all sectors.

Table 37
Eleventh Output Table

Entitled: 1974 Manufacturing Submodel Results - Constant 1974 Dollars

8 Columns: 1-FOOD, 2-TOBACCO, 3-TEXTILE, 4-APPAREL, 5-LUMBER, 6-FURNITURE,
7-PAPER, 8-PRINTING, 9-CHEMICAL, 10-PET&COAL, 11-RUBBER&PLA,
12-LEATHER, 13-STONE&GLASS, 14-PRI. METAL, 15-FAB. METAL,
16-MACHINERY, 17-ELEC. EQUIP, 18-TRANS. EQUIP, 19-INSTRUMENT,
20-OTHER, 21-TOTAL MANUFAC, 22-AGRI, 23-MINING, 24-CONSTRUCT
25-TOTAL A-M-C

32 Rows:

1	PRICE	1974 = 1 (Index)
2	PRODUCT Q	Millions of 1974 dollars worth at 1974 prices
3	PRODUCT V	Millions of current dollars worth at current prices
4	FIN DEM Q	Millions of 1974 dollars worth at 1974 prices
5	FIN DEM V	Millions of current dollars worth at current prices
6	VAL ADDED	Millions of current dollars worth at current prices
7	VA CAP	Millions of current dollars worth at current prices
8	VA TAX	Millions of current dollars worth at current prices
9	VA LABOR	Millions of current dollars worth at current prices
10	LABOR Q	Millions of man-years
11	ELEC SQ	Trillions of BTU's
12	NUC SQ	Trillions of BTU's
13	NAT GAS SQ	Trillions of BTU's
14	LPG SQ	Trillions of BTU's
15	GAS SQ	Trillions of BTU's
16	KERO SQ	Trillions of BTU's
17	DIST SQ	Trillions of BTU's
18	RESID SQ	Trillions of BTU's
19	COAL SQ	Trillions of BTU's
20	EXOT SQ	Trillions of BTU's
21	TOTAL SQ	Trillions of BTU's
22	ELEC C	Millions of current dollars worth at current prices
23	NUC C	Millions of current dollars worth at current prices
24	NATGAS C	Millions of current dollars worth at current prices
25	LPG C	Millions of current dollars worth at current prices
26	GAS C	Millions of current dollars worth at current prices
27	KERO C	Millions of current dollars worth at current prices
28	DIST C	Millions of current dollars worth at current prices
29	RESID C	Millions of current dollars worth at current prices
30	COAL C	Millions of current dollars worth at current prices
31	EXOTIC C	Millions of current dollars worth at current prices
32	TOTAL C	Millions of current dollars worth at current prices

COMPUTER PROGRAM LISTINGS AND DECKS

A Fortran IV computer program, which implements the model described earlier in this report, has been written and provided to the Massachusetts Energy Office as part of this report. Several items were provided to that office as further documentation of the working model. Computer listings attached to this report included:

1. Program Listing - a printout of the Fortran code which is the model program.
2. Input file listings - separate input files for Northern New England, Southern New England, and New England.
3. Output listings - the model program has been run with each input file, and the resulting outputs have been provided. Those computer runs projected the base year from base-year exogenous variables.

In addition, four computer card decks were included with this report. These decks produced the listings described in 1 and 2 above. Since the decks are punched in Hollerith (026) punch, conversion to ASCII (029) punch is required for use with the NEEMIS computer system.

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APPENDIX

The 1974 disaggregated input-output tables for Northern, Southern, and total New England are shown on the following 12 pages. Each of these tables should consist of 40 rows and 28 columns, but due to printing limitations, the values for each row are shown in one unit consisting of 5 rows.

For example, the row corresponding to "food products" appears first. The column values are arranged so that the upper left value would normally be under the first column, the second value in the second column, and so on. The output format is thus:

"Food (20)"	Food (20)	Tobacco (21)	Textiles (23)	Apparel (23)	Lumber (24)	Furniture (25)
	Paper (26)	Prntg. (27)	Clerical (28)	Petrol. (29)	Rub.&Plas.(30)	Leather (31)
	Stone..(32)	Pri.met (33)	Fab.met.(34)	Mach. (35)	Elec.Eq. (36)	Trns.Eq. (37)
	Inst. (38)	Other (39)	Agriculture	Mining	Construction	Comm. Trans.
	Services	Res. Trans.	Res. En. Serv.	Electricity		

I-0 TABLE
NORTHERN NEW ENGLAND
DISAGGREGATED

Food (20)	0.184121	0.0	0.001745	0.0	0.0	0.001232
	0.006667	0.0	0.007833	0.000152	0.000396	0.068632
	0.000667	0.000106	0.000013	0.000245	0.0	0.0
	0.002545	0.002181	0.061279	0.0	0.0	0.000653
	0.001829	0.0	0.0	0.0		
Tobacco (21)	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.000257	0.0	0.0	0.0	0.0
	0.000015	0.0	0.0	0.0		
Textiles (22)	0.000248	0.0	0.254852	0.275761	0.000660	0.076532
	0.010163	0.003389	0.000323	0.0	0.051249	0.040332
	0.007778	0.000143	0.000603	0.000383	0.000423	0.003154
	0.018375	0.027205	0.004618	0.000687	0.002597	0.000138
	0.000165	0.0	0.0	0.0		
Apparel (23)	0.001527	0.0	0.007883	0.224628	0.001315	0.008058
	0.001377	0.000896	0.000888	0.000608	0.002572	0.015028
	0.001111	0.000190	0.001186	0.000744	0.000762	0.001327
	0.002980	0.004619	0.000416	0.003780	0.000624	0.000437
	0.000622	0.0	0.0	0.0		
Lumber (24)	0.001453	0.0	0.000189	0.000075	0.191813	0.154772
	0.059072	0.000234	0.002221	0.001064	0.002770	0.007624
	0.003555	0.001287	0.003893	0.002225	0.000924	0.020394
	0.002038	0.019377	0.001101	0.000286	0.057170	0.000008
	0.000256	0.0	0.0	0.0		
Furn. (25)	0.0	0.0	0.000232	0.000075	0.002520	0.026734
	0.000104	0.000156	0.0	0.0	0.000660	0.000162
	0.0	0.000004	0.002495	0.000480	0.000639	0.002618
	0.003525	0.002438	0.0	0.0	0.006720	0.0
	0.000063	0.0	0.0	0.0		
Paper (26)	0.031994	0.0	0.004938	0.007720	0.004791	0.017429
	0.162917	0.131934	0.013973	0.068216	0.020246	0.016453
	0.029220	0.000487	0.010065	0.002868	0.012737	0.004729
	0.030721	0.053762	0.002569	0.007216	0.003380	0.000382
	0.002543	0.0	0.0	0.0		
Prntg. (27)	0.006257	0.0	0.000424	0.000444	0.000110	0.000324
	0.007080	0.094793	0.000202	0.000228	0.000528	0.000487
	0.000333	0.000177	0.000432	0.003181	0.000289	0.000211
	0.000513	0.004491	0.000171	0.0	0.000035	0.000197
	0.004984	0.0	0.0	0.0		
Clerical (28)	0.009410	0.0	0.104847	0.022661	0.010288	0.022917
	0.042850	0.018114	0.220592	0.022562	0.186798	0.027539
	0.030665	0.005448	0.012854	0.002493	0.019646	0.015094
	0.039455	0.042344	0.020078	0.017795	0.017265	0.000452
	0.015807	0.0	0.0	0.0		
Petrol. (29)	0.000012	0.0	0.0	0.0	0.000073	0.0
	0.0	0.0	0.000525	0.010180	0.000066	0.0
	0.004112	0.0	0.000414	0.000084	0.0	0.0
	0.000008	0.0	0.000056	0.004811	0.011490	0.0
	0.000171	0.0	0.0	0.0		

Rubber and plastics (30)	0.008541	0.0	0.004560	0.002093	0.002237	0.053005
	0.015300	0.003818	0.003835	0.008204	0.037068	0.060484
	0.013550	0.000836	0.007417	0.007626	0.016086	0.012841
	0.028302	0.046570	0.002116	0.010197	0.008668	0.001129
	0.001666	0.0	0.0	0.0		
Leather (31)	0.000012	0.0	0.000077	0.003567	0.000073	0.000881
	0.000104	0.000039	0.000040	0.000380	0.001913	0.175947
	0.000333	0.000084	0.000141	0.000226	0.000049	0.000114
	0.000979	0.007057	0.000163	0.0	0.0	0.0
	0.000309	0.0	0.0	0.0		
Stone, clay & glass (32)	0.012438	0.0	0.003706	0.000054	0.004358	0.014697
	0.001651	0.0	0.002907	0.041021	0.006793	0.000529
	0.137093	0.000782	0.007128	0.007335	0.023473	0.004532
	0.008896	0.007442	0.000316	0.040974	0.082457	0.000205
	0.000614	0.0	0.0	0.0		
Primary metals (33)	0.000223	0.0	0.000077	0.0	0.002268	0.043578
	0.000608	0.001948	0.020431	0.000304	0.003957	0.000162
	0.016772	0.106540	0.315486	0.104531	0.089846	0.118305
	0.089728	0.079166	0.000024	0.020334	0.047616	0.001286
	0.000178	0.0	0.0	0.0		
Fab. metals (34)	0.029817	0.0	0.000341	0.001498	0.010692	0.074337
	0.009818	0.009040	0.013037	0.007597	0.019126	0.014052
	0.015559	0.004894	0.071101	0.044574	0.034009	0.049208
	0.062078	0.035285	0.004537	0.005758	0.128229	0.000885
	0.001706	0.0	0.0	0.0		
Mach. (35)	0.003017	0.0	0.005274	0.000912	0.003730	0.006604
	0.006111	0.001363	0.013767	0.002811	0.008508	0.004140
	0.024895	0.007047	0.048655	0.144625	0.023636	0.071120
	0.034603	0.007570	0.002664	0.027984	0.021336	0.000889
	0.001556	0.0	0.0	0.0		
Elec. Eq. (36)	0.000087	0.0	0.000501	0.000231	0.000477	0.002389
	0.000701	0.000468	0.001009	0.009344	0.001451	0.000649
	0.004445	0.004130	0.011321	0.067894	0.145549	0.044209
	0.114005	0.017324	0.000638	0.002088	0.029094	0.000511
	0.001927	0.0	0.0	0.0		
Trans. Equip. (37)	0.000050	0.0	0.000077	0.000028	0.000477	0.002983
	0.0	0.000195	0.001171	0.000836	0.004551	0.000162
	0.000111	0.000905	0.014312	0.013429	0.013043	0.195027
	0.024055	0.006672	0.001137	0.000052	0.000058	0.003096
	0.001112	0.0	0.0	0.0		
Instr. (38)	0.000161	0.0	0.000264	0.000908	0.000220	0.003832
	0.001606	0.007208	0.000606	0.000304	0.001187	0.002271
	0.000667	0.000204	0.004812	0.003009	0.005976	0.013383
	0.130042	0.001925	0.0	0.0	0.003502	0.000197
	0.001359	0.0	0.0	0.0		
Other (39)	0.000112	0.0	0.000734	0.014163	0.000841	0.003821
	0.000706	0.001403	0.000807	0.000684	0.006068	0.006915
	0.004555	0.000244	0.001092	0.000812	0.000513	0.001625
	0.006827	0.075576	0.000272	0.000026	0.002353	0.000063
	0.001216	0.0	0.0	0.0		
Agr.	0.336260	0.0	0.054291	0.007320	0.041247	0.0
	0.0	0.0	0.001979	0.0	0.0	0.003964
	0.0	0.0	0.0	0.0	0.0	0.0
	0.001763	0.001539	0.306782	0.0	0.003040	0.000173
	0.002049	0.0	0.0	0.0		

Mining	0.000149	0.0	0.000038	0.0	0.000073	0.0
	0.004126	0.0	0.031736	0.047177	0.001187	0.0
	0.095671	0.017728	0.000221	0.0	0.000414	0.0
	0.001175	0.000513	0.001018	0.029900	0.010804	0.000004
	0.000037	0.0	0.0	0.0		
Constr.	0.003190	0.0	0.002345	0.001147	0.002638	0.004350
	0.006095	0.003078	0.006500	0.0	0.003298	0.001502
	0.011001	0.001541	0.003510	0.003079	0.002930	0.003149
	0.005108	0.002951	0.006514	0.006601	0.000347	0.005141
	0.007543	0.0	0.0	0.0		
Comm. Trans.	0.032182	0.0	0.013618	0.006848	0.021548	0.025173
	0.029722	0.009936	0.024670	0.047626	0.015702	0.013867
	0.072222	0.010080	0.015889	0.007284	0.007896	0.012082
	0.010134	0.017324	0.017192	0.010623	0.030267	0.020567
	0.002993	0.0	0.0	0.0		
Services	0.102921	0.0	0.046814	0.075126	0.046707	0.115390
	0.069365	0.126333	0.083932	0.409154	0.080858	0.098269
	0.111108	0.022921	0.084978	0.093096	0.083980	0.090189
	0.169751	0.135905	0.088726	0.093449	0.178754	0.030319
	0.095838	0.0	0.0	0.0		
Res. Trans.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Res. energy services	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Elec.	0.010870	0.0	0.021280	0.003170	0.011980	0.013040
	0.049480	0.011220	0.009463	0.0	0.023490	0.008406
	0.027930	0.0	0.011600	0.010640	0.006235	0.002441
	0.006592	0.018340	0.0	0.0	0.0	0.0
	0.017380	0.0	0.543600	0.0		
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Nat. gas	0.001238	0.0	0.006155	0.0	0.000486	0.0
	0.000871	0.001573	0.007324	0.0	0.000359	0.0
	0.011800	0.003005	0.000093	0.000612	0.0	0.0
	0.0	0.0	0.002325	0.0	0.000045	0.0
	0.001676	0.0	0.033180	0.125200		
LPG	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.016370	0.0		
GAS	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.002667	0.0	0.000174	0.255300
	0.000884	0.999800	0.0	0.0		

Kero.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.052820	0.0		
Dist.	0.003896	0.0	0.001991	0.000108	0.002543	0.002175
	0.054570	0.001338	0.007037	0.0	0.004081	0.001740
	0.006116	0.0	0.002256	0.002766	0.003148	0.000562
	0.000900	0.0	0.000953	0.0	0.0	0.036950
	0.012570	0.0	0.349000	0.135300		
Resid.	0.002090	0.0	0.003671	0.000041	0.000639	0.000044
	0.023730	0.000321	0.000831	0.0	0.001577	0.000611
	0.007130	0.000276	0.000660	0.000329	0.000030	0.0
	0.0	0.000576	0.0	0.0	0.0	0.0
	0.003223	0.0	0.0	2.930000		
Coal	0.000092	0.0	0.000887	0.000129	0.000155	0.000067
	0.000177	0.004043	0.000031	0.0	0.000294	0.000080
	0.000883	0.000421	0.000021	0.0	0.000018	0.000016
	0.000030	0.000802	0.0	0.0	0.0	0.0
	0.000011	0.0	0.000313	1.918000		
Exotic	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Wages	0.119200	0.0	0.291700	0.262300	0.300900	0.235600
	0.248400	0.393000	0.277500	0.145600	0.325400	0.307400
	0.239900	0.425000	0.253100	0.333300	0.358700	0.224100
	0.147100	0.277600	0.209200	0.199100	0.206100	0.271600
	0.301700	0.0	0.0	0.0		
Taxes	0.040980	0.0	0.009488	0.005855	0.013440	0.007024
	0.011730	0.011260	0.015230	0.030450	0.052650	0.008495
	0.009017	0.018620	0.008450	0.010630	0.010750	0.013350
	0.004202	0.008600	0.023470	0.055640	0.008075	0.055260
	0.126200	0.0	0.0	0.0		
Prop. Income	0.057450	0.0	0.157000	0.083140	0.320700	0.083010
	0.174900	0.162900	0.229600	0.145500	0.135200	0.114100
	0.111800	0.366900	0.105800	0.131500	0.138300	0.096220
	0.053570	0.094590	0.239000	0.462700	0.139800	0.314160
	0.389800	0.0	0.0	0.0		

* Input-output coefficients are value fraction spent on indicated input per unit output.
Rows represent inputs and columns represent outputs.

I-O TABLE
SOUTHERN NEW ENGLAND
DISAGGREGATED

Food (20)	0.170205	0.000250	0.001944	0.0	0.0	0.000903
	0.004264	0.0	0.015713	0.000122	0.000487	0.093560
	0.000541	0.000265	0.000041	0.000214	0.0	0.0
	0.001080	0.002429	0.052584	0.0	0.0	0.002235
	0.002956	0.0	0.0	0.0		
Tob. (21)	0.0	0.416887	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.000286	0.0	0.0	0.0	0.0
	0.000028	0.0	0.0	0.0		
Tex. (22)	0.000230	0.0	0.257889	0.319752	0.001029	0.061637
	0.006633	0.004140	0.001814	0.0	0.063047	0.033668
	0.006312	0.000355	0.000947	0.000395	0.000529	0.003160
	0.008057	0.030294	0.025548	0.000357	0.002769	0.000471
	0.000354	0.0	0.0	0.0		
App. (23)	0.001412	0.000501	0.010418	0.214884	0.002071	0.008189
	0.001135	0.001095	0.000694	0.000489	0.003164	0.012634
	0.001120	0.000505	0.001063	0.000778	0.000673	0.003507
	0.001664	0.005143	0.000910	0.001963	0.000666	0.001494
	0.001424	0.0	0.0	0.0		
Lum. (24)	0.001343	0.001753	0.000196	0.000299	0.301185	0.128962
	0.037939	0.000286	0.000902	0.000857	0.003407	0.006337
	0.004545	0.003315	0.003706	0.002148	0.001459	0.016019
	0.000997	0.021577	0.002368	0.000147	0.060963	0.000027
	0.000413	0.0	0.0	0.0		
Furn (25)	0.0	0.0	0.000374	0.000299	0.003970	0.031020
	0.000104	0.000190	0.0	0.0	0.000811	0.000135
	0.000742	0.000014	0.001730	0.000640	0.005194	0.002235
	0.001495	0.002715	0.0	0.0	0.007166	0.0
	0.000098	0.0	0.0	0.0		
Pa. (26)	0.029575	0.027547	0.005623	0.010048	0.007520	0.016512
	0.198887	0.161157	0.030688	0.054936	0.024907	0.014673
	0.033591	0.001250	0.011729	0.003542	0.009952	0.005842
	0.027806	0.059866	0.013978	0.003747	0.003604	0.001306
	0.004054	0.0	0.0	0.0		
Pr. (27)	0.005784	0.008517	0.000628	0.000415	0.000171	0.000420
	0.005762	0.115789	0.001128	0.000184	0.000649	0.000405
	0.000314	0.000447	0.002832	0.004410	0.000780	0.000238
	0.000750	0.005001	0.000146	0.0	0.000037	0.000673
	0.011287	0.0	0.0	0.0		
Cl. (28)	0.008699	0.028800	0.116397	0.022091	0.016098	0.020438
	0.033498	0.022126	0.256624	0.018170	0.229800	0.036442
	0.029738	0.014133	0.013685	0.002719	0.012805	0.018571
	0.049489	0.047152	0.024486	0.009231	0.018410	0.001548
	0.024672	0.0	0.0	0.0		
Pet. (29)	0.000011	0.0	0.0	0.0	0.000114	0.0
	0.0	0.0	0.000224	0.008199	0.000081	0.0
	0.003337	0.0	0.000114	0.000089	0.000038	0.000060
	0.000017	0.0	0.000339	0.002498	0.012253	0.0
	0.000280	0.0	0.0	0.0		

R&P (30)	0.007895	0.012274	0.006207	0.004276	0.003487	0.048983
	0.010751	0.004664	0.021699	0.006607	0.045601	0.050709
	0.015014	0.002131	0.010173	0.008627	0.013887	0.014778
	0.020386	0.051858	0.003434	0.005296	0.009243	0.003864
	0.003154	0.0	0.0	0.0		
Lea. (31)	0.000011	0.0	0.000125	0.003791	0.000114	0.000737
	0.000104	0.000048	0.000010	0.000306	0.002353	0.163747
	0.000271	0.000214	0.000231	0.000210	0.000130	0.000111
	0.000415	0.007858	0.000208	0.0	0.0	0.0
	0.000920	0.0	0.0	0.0		
Stone, clay & (32) glass	0.011498	0.0	0.003801	0.000079	0.006815	0.013783
	0.001121	0.0	0.008723	0.033035	0.008357	0.000725
	0.124616	0.002107	0.005137	0.007089	0.015456	0.005349
	0.010830	0.008287	0.000289	0.021274	0.087927	0.000700
	0.001115	0.0	0.0	0.0		
Primary metals (33)	0.000207	0.0	0.000125	0.0	0.003557	0.057250
	0.002333	0.002380	0.006912	0.000245	0.004868	0.000135
	0.014840	0.274913	0.266066	0.108652	0.067308	0.123330
	0.066414	0.088154	0.000019	0.010553	0.050775	0.004402
	0.000358	0.0	0.0	0.0		
Fab. metals (34)	0.027563	0.004008	0.000359	0.002716	0.016731	0.071828
	0.009408	0.011042	0.021234	0.006118	0.023529	0.011822
	0.012844	0.013207	0.052202	0.044769	0.032553	0.058746
	0.043773	0.039291	0.019036	0.002989	0.136735	0.003029
	0.003185	0.0	0.0	0.0		
Mach. (35)	0.002789	0.001753	0.005837	0.001196	0.005856	0.008678
	0.005709	0.001665	0.006519	0.002264	0.010467	0.004012
	0.020943	0.018930	0.037047	0.160118	0.022720	0.070225
	0.017869	0.008429	0.003631	0.014514	0.022751	0.003043
	0.003198	0.0	0.0	0.0		
Elec. Eq. (36)	0.000080	0.0	0.000753	0.000245	0.000743	0.003213
	0.000482	0.000571	0.000604	0.007525	0.001785	0.000539
	0.003913	0.010742	0.006329	0.083160	0.168959	0.054629
	0.069115	0.019291	0.001153	0.001084	0.031024	0.001750
	0.004183	0.0	0.0	0.0		
Trans. Eq. (37)	0.000046	0.0	0.000125	0.000112	0.000743	0.004563
	0.0	0.000238	0.000412	0.000673	0.005599	0.000135
	0.000702	0.002444	0.012530	0.013973	0.013511	0.266798
	0.011134	0.007429	0.005718	0.000027	0.000062	0.010597
	0.001715	0.0	0.0	0.0		
Inst. (38)	0.000149	0.000250	0.000263	0.001450	0.000343	0.004910
	0.001131	0.008804	0.002104	0.000245	0.001460	0.001888
	0.000890	0.000580	0.003019	0.003575	0.006612	0.016978
	0.096947	0.002143	0.0	0.0	0.003734	0.000673
	0.002714	0.0	0.0	0.0		
Other (39)	0.000103	0.0	0.001156	0.014201	0.001321	0.003621
	0.000523	0.001714	0.000760	0.000551	0.007464	0.005891
	0.004003	0.000624	0.001580	0.000862	0.001336	0.001336
	0.004493	0.084157	0.001392	0.000013	0.002509	0.000215
	0.002895	0.0	0.0	0.0		
Agri.	0.310845	0.356422	0.053419	0.006840	0.064304	0.0
	0.0	0.0	0.001904	0.0	0.0	0.005434
	0.0	0.0	0.0	0.0	0.0	0.0
	0.000748	0.001714	0.460263	0.0	0.003242	0.000592
	0.004836	0.0	0.0	0.0		

Mining	0.000138	0.0	0.000033	0.0	0.000114	0.0
	0.002616	0.0	0.008750	0.037993	0.001460	0.0
	0.079654	0.046439	0.000303	0.0	0.000147	0.0
	0.000498	0.000572	0.001090	0.015491	0.011521	0.000013
	0.000091	0.0	0.0	0.0		
Const.	0.002949	0.001753	0.002393	0.001186	0.004122	0.004192
	0.004838	0.003760	0.005344	0.0	0.004057	0.001534
	0.010325	0.004241	0.002979	0.003196	0.002694	0.003585
	0.004830	0.003286	0.005510	0.003425	0.000370	0.017595
	0.017331	0.0	0.0	0.0		
Comm.	0.029750	0.008767	0.015082	0.007259	0.033799	0.022096
Trans.	0.027342	0.012137	0.019161	0.038354	0.019316	0.015949
	0.063329	0.027073	0.013160	0.007712	0.007044	0.013750
	0.008824	0.019291	0.027643	0.005504	0.032275	0.070387
	0.005654	0.0	0.0	0.0		
Services	0.095142	0.130516	0.050785	0.077560	0.073248	0.106290
	0.061203	0.154315	0.160365	0.329501	0.099472	0.100626
	0.105552	0.060207	0.066507	0.101868	0.082269	0.103391
	0.132408	0.151335	0.112394	0.048498	0.190612	0.103764
	0.164534	0.0	0.0	0.0		
Res. trans.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Resid. ener. services	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Elec.	0.006738	0.0	0.016350	0.004043	0.008349	0.004696
	0.022620	0.006685	0.013320	0.009674	0.020210	0.005740
	0.016160	0.018310	0.012070	0.007283	0.009147	0.004301
	0.006060	0.008451	0.0	0.0	0.0	0.0
	0.013510	0.0	0.459700	0.0		
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Nat.gas	0.002619	0.0	0.005513	0.000382	0.000909	0.000518
	0.002628	0.000929	0.003202	0.000741	0.001984	0.000398
	0.010790	0.007757	0.004216	0.001350	0.001416	0.000680
	0.001640	0.001225	0.000611	0.0	0.000043	0.0
	0.003940	0.0	0.179100	0.071610		
LPG	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.004883	0.0		
Gas	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.000705	0.0	0.000168	0.161500
	0.000459	1.000000	0.0	0.0		

Kero.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.008365	0.0		
Dist.	0.001442	0.0	0.003584	0.000275	0.004188	0.001782
	0.008410	0.000741	0.001968	0.006803	0.001774	0.000936
	0.007095	0.002936	0.001844	0.000757	0.000689	0.000404
	0.000973	0.001141	0.002964	0.0	0.0	0.022700
	0.006272	0.0	0.345700	0.059580		
Resid.	0.000756	0.0	0.003442	0.000098	0.001284	0.000827
	0.009049	0.000086	0.005693	0.001049	0.001775	0.000787
	0.002567	0.001703	0.001046	0.000464	0.000545	0.000456
	0.000560	0.000565	0.0	0.0	0.0	0.0
	0.003368	0.0	0.0	2.932000		
Coal	0.0	0.0	0.000012	0.000025	0.000137	0.001597
	0.001240	0.0	0.000270	0.000053	0.000135	0.000049
	0.0	0.0	0.000094	0.000005	0.000008	0.000001
	0.0	0.0	0.0	0.0	0.0	0.0
	0.000005	0.0	0.000258	0.151800		
Exotic	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Wages	0.155600	0.0	0.279500	0.234600	0.200800	0.285800
	0.304200	0.343600	0.218900	0.146400	0.301000	0.306700
	0.286600	0.257700	0.325500	0.309000	0.368100	0.160900
	0.296100	0.235100	0.141300	0.215200	0.207000	0.307600
	0.276000	0.0	0.0	0.0		
Taxes	0.053150	0.0	0.008969	0.005098	0.009378	0.007724
	0.014570	0.009739	0.011960	0.030010	0.042730	0.008592
	0.010450	0.011360	0.010920	0.009593	0.011040	0.008800
	0.008230	0.007480	0.017300	0.066790	0.003243	0.049820
	0.106700	0.0	0.0	0.0		
Prop.	0.073270	0.0	0.148700	0.066780	0.227500	0.078830
Income	0.221500	0.132100	0.172400	0.258900	0.068250	0.115800
	0.129200	0.216100	0.131200	0.112800	0.143000	0.041820
	0.106400	0.078480	0.074980	0.571400	0.100900	0.230000
	0.328300	0.0	0.0	0.0		

* Input-output coefficients are value fraction spent on indicated input per unit output.
Rows represent inputs and columns represent outputs.

I-0 Table
NEW ENGLAND
DISAGGREGATED

Food (22)	0.173757	0.000250	0.001906	0.0	0.0	0.000978
	0.005287	0.0	0.015382	0.000124	0.000474	0.081924
	0.000564	0.000259	0.000039	0.000218	0.0	0.0
	0.001170	0.002421	0.060384	0.0	0.0	0.001988
	0.002835	0.0	0.0	0.0		
Tobacco (21)	0.0	0.416887	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.000285	0.0	0.0	0.0	0.0
	0.000026	0.0	0.0	0.0		
Textiles (22)	0.000234	0.0	0.257396	0.315370	0.000781	0.065056
	0.008138	0.004056	0.001750	0.0	0.061369	0.036782
	0.006575	0.000347	0.000928	0.000394	0.000511	0.003167
	0.008693	0.030191	0.014483	0.000485	0.002742	0.000419
	0.000328	0.0	0.0	0.0		
Apparel (23)	0.001441	0.000501	0.009920	0.215917	0.001561	0.008165
	0.001239	0.001072	0.000703	0.000497	0.003080	0.013750
	0.001119	0.000492	0.001072	0.000776	0.000688	0.003387
	0.001747	0.005126	0.000665	0.002668	0.000659	0.001330
	0.001312	0.0	0.0	0.0		
Lumber (24)	0.001371	0.001753	0.000195	0.000277	0.227489	0.134876
	0.046940	0.000280	0.000960	0.000869	0.003317	0.006939
	0.004371	0.003234	0.003723	0.002158	0.001369	0.016311
	0.001062	0.021504	0.001740	0.000200	0.060373	0.000024
	0.000396	0.0	0.0	0.0		
Furn. (25)	0.0	0.0	0.000346	0.000277	0.002992	0.030070
	0.000104	0.000186	0.0	0.0	0.000790	0.000148
	0.000611	0.000013	0.001778	0.000623	0.004432	0.002262
	0.001619	0.002706	0.0	0.0	0.007097	0.0
	0.000094	0.0	0.0	0.0		
Paper (26)	0.030193	0.027547	0.005489	0.009813	0.005681	0.016734
	0.183947	0.157876	0.029986	0.055753	0.024244	0.015507
	0.032824	0.001219	0.011652	0.003472	0.010414	0.005790
	0.028093	0.059663	0.007953	0.005093	0.003569	0.001162
	0.003896	0.0	0.0	0.0		
Prntg. (27)	0.005904	0.008517	0.000587	0.000418	0.000130	0.000399
	0.006328	0.113432	0.001089	0.000186	0.000632	0.000443
	0.000318	0.000437	0.002697	0.004287	0.000698	0.000237
	0.000739	0.004984	0.000168	0.0	0.000037	0.000599
	0.010406	0.0	0.0	0.0		
Clerical (28)	0.008881	0.028800	0.114153	0.022159	0.012186	0.021020
	0.037503	0.021676	0.255183	0.018440	0.223684	0.032286
	0.029916	0.013785	0.013656	0.002693	0.013954	0.018413
	0.049096	0.046992	0.023126	0.012550	0.018232	0.001378
	0.023780	0.0	0.0	0.0		
Petrol. (29)	0.000012	0.0	0.0	0.0	0.000087	0.0
	0.0	0.0	0.000237	0.008320	0.000079	0.0
	0.003476	0.0	0.000132	0.000088	0.000032	0.000056
	0.000016	0.0	0.000189	0.003395	0.012134	0.0
	0.000268	0.0	0.0	0.0		

Rubber and plastics (30)	0.008060	0.012274	0.005880	0.004054	0.002646	0.049933
	0.012690	0.004569	0.020929	0.006705	0.044388	0.055280
	0.014771	0.002079	0.010033	0.008527	0.014258	0.014700
	0.020936	0.051682	0.002830	0.007201	0.009154	0.003438
	0.002966	0.0	0.0	0.0		
Leather (31)	0.000012	0.0	0.000115	0.003769	0.000087	0.000770
	0.000104	0.000047	0.000011	0.000310	0.002290	0.169442
	0.000282	0.000209	0.000226	0.000212	0.000116	0.000112
	0.000450	0.007832	0.000192	0.0	0.0	0.0
	0.000828	0.0	0.0	0.0		
Stone, clay, glass (32)	0.011737	0.0	0.003783	0.000076	0.005162	0.014001
	0.001347	0.0	0.008475	0.033527	0.008135	0.000633
	0.126957	0.002052	0.005263	0.007119	0.016800	0.005312
	0.010761	0.008259	0.000320	0.028917	0.087076	0.000623
	0.001053	0.0	0.0	0.0		
Primary metals (33)	0.000211	0.0	0.000115	0.0	0.002689	0.054196
	0.001607	0.002332	0.007508	0.000248	0.004739	0.000148
	0.015193	0.268153	0.269365	0.108313	0.071098	0.123316
	0.068046	0.087856	0.000023	0.014347	0.050283	0.003917
	0.000334	0.0	0.0	0.0		
Fab. metals (34)	0.028139	0.004008	0.000356	0.002593	0.012665	0.072448
	0.009599	0.010817	0.020899	0.006209	0.022903	0.012866
	0.013329	0.012857	0.053401	0.044752	0.032805	0.058323
	0.045018	0.039158	0.011446	0.004063	0.135412	0.002695
	0.003000	0.0	0.0	0.0		
Mach. (35)	0.002847	0.001753	0.005727	0.001167	0.004423	0.008215
	0.005888	0.001631	0.006841	0.002297	0.010188	0.004071
	0.021652	0.018435	0.037798	0.158576	0.022880	0.070430
	0.018924	0.008401	0.003245	0.019739	0.022531	0.002707
	0.002979	0.0	0.0	0.0		
Elec. Eq. (36)	0.000082	0.0	0.000703	0.000243	0.000564	0.003028
	0.000575	0.000559	0.000622	0.007637	0.001737	0.000591
	0.004009	0.010471	0.006633	0.081521	0.165040	0.054147
	0.072017	0.019226	0.000908	0.001473	0.030724	0.001558
	0.003874	0.0	0.0	0.0		
Trans. Eq. (37)	0.000047	0.0	0.000115	0.000104	0.000564	0.004209
	0.0	0.000233	0.000446	0.000683	0.005450	0.000148
	0.000597	0.002379	0.012654	0.013908	0.013436	0.263307
	0.011934	0.007404	0.003304	0.000036	0.000061	0.009430
	0.001656	0.0	0.0	0.0		
Instr. (38)	0.000152	0.000250	0.000264	0.001395	0.000260	0.004670
	0.001333	0.008625	0.002040	0.000248	0.001421	0.002067
	0.000851	0.000563	0.003130	0.003510	0.006507	0.016816
	0.099284	0.002136	0.0	0.0	0.003698	0.000599
	0.002535	0.0	0.0	0.0		
Other (39)	0.000105	0.0	0.001072	0.014209	0.000997	0.003669
	0.000601	0.001679	0.000763	0.000559	0.007266	0.006370
	0.004103	0.000609	0.001554	0.000856	0.001199	0.001356
	0.004647	0.083872	0.000802	0.000018	0.002484	0.000192
	0.002655	0.0	0.0	0.0		
Agri.	0.317331	0.356422	0.053628	0.006891	0.048804	0.0
	0.0	0.0	0.001908	0.0	0.0	0.004748
	0.0	0.0	0.0	0.0	0.0	0.0
	0.000810	0.001708	0.393012	0.0	0.003210	0.000527
	0.004441	0.0	0.0	0.0		

Kero.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.017330	0.0		
Dist.	0.002068	0.0	0.003287	0.000258	0.003079	0.001875
	0.029160	0.000808	0.002173	0.006387	0.002102	0.001313
	0.006914	0.002816	0.001871	0.000957	0.001115	0.000410
	0.000968	0.001103	0.002101	0.0	0.0	0.024940
	0.007042	0.0	0.346300	0.066200		
Resid.	0.001096	0.0	0.003485	0.000093	0.000849	0.000642
	0.015650	0.000113	0.005496	0.000985	0.001747	0.000704
	0.003412	0.001645	0.001020	0.000450	0.000456	0.000436
	0.000521	0.000566	0.0	0.0	0.0	0.0
	0.003199	0.0	0.0	2.934000		
Coal	0.000024	0.0	0.000175	0.000035	0.000149	0.001235
	0.000762	0.000455	0.000261	0.000050	0.000158	0.000063
	0.000163	0.000017	0.000089	0.000004	0.000009	0.000002
	0.000002	0.000027	0.0	0.0	0.0	0.0
	0.000006	0.0	0.000269	0.305400		
Exotic	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Wages	0.146300	0.0	0.281800	0.237300	0.268200	0.273900
	0.279100	0.349200	0.221300	0.146400	0.304500	0.307000
	0.278000	0.264500	0.320700	0.311400	0.366500	0.163600
	0.285700	0.236500	0.170400	0.209000	0.206800	0.302000
	0.279100	0.0	0.0	0.0		
Taxes	0.050050	0.0	0.009066	0.005172	0.012120	0.007559
	0.013290	0.009911	0.012090	0.030000	0.044130	0.008546
	0.010190	0.011660	0.010750	0.009697	0.010990	0.008994
	0.007949	0.007518	0.019950	0.062460	0.004006	0.050670
	0.109100	0.0	0.0	0.0		
Prop. Income	0.069240	0.0	0.150300	0.068370	0.290300	0.079820
	0.200500	0.135500	0.174700	0.251900	0.077760	0.115000
	0.126000	0.222200	0.129500	0.114700	0.142200	0.044150
	0.102700	0.079020	0.145400	0.529200	0.107000	0.243060
	0.335800	0.0	0.0	0.0		

* Input-output coefficients are value fraction input on indicated input per unit output. Rows represent inputs; columns represent outputs.

Mining	0.000141	0.0	0.000034	0.0	0.000087	0.0
	0.003259	0.0	0.009760	0.038558	0.001421	0.0
	0.082528	0.045268	0.000299	0.0	0.000192	0.0
	0.000540	0.000570	0.001103	0.021073	0.011409	0.000012
	0.000083	0.0	0.0	0.0		
Constr.	0.003011	0.001753	0.002384	0.001182	0.003123	0.004232
	0.005377	0.003683	0.005398	0.0	0.003949	0.001519
	0.010450	0.004126	0.003016	0.003187	0.002734	0.003568
	0.004866	0.003275	0.006382	0.004657	0.000367	0.015657
	0.015956	0.0	0.0	0.0		
Comm. Trans.	0.030371	0.008767	0.014798	0.007218	0.025547	0.022806
	0.028391	0.011890	0.019416	0.038925	0.018802	0.014983
	0.064932	0.026364	0.013338	0.007672	0.007187	0.013684
	0.008937	0.019226	0.022872	0.007489	0.031963	0.062635
	0.005317	0.0	0.0	0.0		
Services	0.097128	0.130516	0.050017	0.077338	0.055365	0.108427
	0.064743	0.151174	0.157144	0.334403	0.096824	0.099529
	0.106583	0.058680	0.067703	0.101038	0.082566	0.102843
	0.135133	0.150823	0.104110	0.065936	0.188767	0.092336
	0.156571	0.0	0.0	0.0		
Res. Trans.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Res. Energy Serv.	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Elec.	0.007790	0.0	0.017270	0.003958	0.010790	0.006672
	0.034700	0.007195	0.013160	0.009083	0.020670	0.006991
	0.018340	0.017570	0.012040	0.007617	0.008642	0.004221
	0.006097	0.008784	0.0	0.0	0.0	0.0
	0.013990	0.0	0.476600	0.0		
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
Nat. gas	0.002267	0.0	0.005633	0.000345	0.000624	0.000396
	0.001838	0.001001	0.003370	0.000696	0.001753	0.000211
	0.010970	0.007563	0.003943	0.001277	0.001171	0.000651
	0.001526	0.001183	0.001347	0.0	0.000044	0.0
	0.003663	0.0	0.149700	0.076310		
LPG	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.007200	0.0		
Gas	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.001547	0.0	0.000169	0.176100
	0.000511	1.000000	0.0	0.0		

OTHER INPUT FACTORS FOR THE NEME MODEL - BASE YEAR

	NORTH	SOUTH
labor norm price	7426	8632
fec	221	847.7
otem	.2774	.9519
gem	879.73 1002.39 91.83 717.43	1985.6 2471 254.9 9978.5
electr. rel. s.w.f.	.5544	.64443
electr. v.a. coeff prop. inc.	.1918	.0230965
electr. labor-use coeff.	.152660E-03	.13131E-03
comm. tr. inter. I-0 column	.4405E-02 .8719E-02 .17032E-01 .25110E-01	.1762E-01 .3488E-01 .6813E-01 .10046E-00

OTHER INPUT FACTORS FOR THE NEME MODEL - BASE YEAR

	NORTH	SOUTH
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electr. labor-use coeff.	.152660E-03	.13131E-03
comm. tr. inter. I-0 column	.4405E-02 .8719E-02 .17032E-01 .25110E-01	.1762E-01 .3488E-01 .6813E-01 .10046E-00

Table 21
Southern Region
1974 Energy Usage
(in trillions of btu's)

Aggregated

	<u>Elect.</u>	<u>Nuc.</u>	<u>N. G.</u>	<u>LPG</u>	<u>Gas</u>	<u>Kero.</u>	<u>Dist.</u>	<u>Resid.</u>	<u>Coal</u>	<u>Exotic</u>
AMC	0	0	0.439	0	.833	0	1.655	0	0	0
Mfg.	52.384	0	41.104	0	0	0	35.538	69.739	4.2463	0
Comm.										
Trans.	0	0	0	0	143.914	0	32.049	0	0	0
Ser.	59.307	0	59.883	0	7.128	0	154.201	194.63	.253	0
Res. Tr.	0	0	0	0	362.826	0	0	0	0	0
Res. En.										
Ser.	68.549	0	136.080	7.762	0	6.706	296.125	0	.4696	0
Elec.	0	37.05*	10.071	0	0	0	8.380	412.41	21.343	2.76*

Disaggregated

Agr.	0	0	.274	0	.276	0	1.655	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0
Const.	0	0	.165	0	.557	0	0	0	0	0

SIC#

20	2.449	0	3.075	0	0	0	2.108	2.596	0	0
21	0	0	0	0	0	0	0	0	0	0
22	3.200	0	3.485	0	0	0	2.821	6.367	.020	0
23	.783	0	.239	0	0	0	.214	.180	.041	0
24	.293	0	.103	0	0	0	.591	.426	.041	0
25	.289	0	.103	0	0	0	.441	.481	.840	0
26	4.145	0	1.555	0	0	0	6.197	15.671	1.941	0
27	1.598	0	.717	0	0	0	.712	.195	0	0
28	3.531	0	2.742	0	0	0	2.098	14.264	.612	0
29	.279	0	.069	0	0	0	.789	.286	.013	0
30	4.525	0	1.435	0	0	0	1.598	3.758	.259	0
31	.456	0	.102	0	0	0	.299	.591	.033	0
32	1.922	0	4.144	0	0	0	3.394	2.886	0	0
33	4.795	0	6.560	0	0	0	3.091	4.215	0	0
34	5.632	0	6.355	0	0	0	3.460	4.612	.375	0
35	5.136	0	3.075	0	0	0	2.147	3.091	.028	0
36	4.847	0	2.424	0	0	0	1.468	2.729	.035	0
37	4.218	0	2.153	0	0	0	1.592	4.227	.008	0
38	1.876	0	1.640	0	0	0	1.211	1.640	0	0
39	2.410	0	1.128	0	0	0	1.309	1.524	0	0

* These two figures represent the total electrical energy produced from these energy sources (implied efficiency of 1.0). In the computer simulation and in the output, these will be lumped together into 39.81 of "Nuclear" capacity, which is allocated to users before other electricity is generated.

Table 22
New England
1974 Energy Usage
(in trillions of btu's)

	<u>Aggregated</u>									
	<u>Elect.</u>	<u>Nuc.</u>	<u>N. G.</u>	<u>LPG</u>	<u>Gas</u>	<u>Kero.</u>	<u>Dist.</u>	<u>Resid.</u>	<u>Coal</u>	<u>Exotic</u>
AMC	0	0	1.255	0	1.725	0	2.055	0	0	0
Mfg.	68.291	0	44.794	0	0	0	76.603	111.286	6.5803	0
Comm.										
Trans.	0	0	0	0	185.684	0	41.633	0	0	0
Ser.	69.937	0	63.433	0	9.041	0	197.261	220.588	.3305	0
Res. Tr.	0	0	0	0	468.135	0	0	0	0	0
Res. En.										
Serv.	89.030	0	142.450	14.337	0	17.404	371.658	0	.6135	0
Elec.	0	57.72*	11.746	0	0	0	10.190	451.61	47.007	15.78*

	<u>Disaggregated</u>									
Agr.	0	0	1.058	0	1.061	0	2.055	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0
Const.	0	0	.197	0	.665	0	0	0	0	0

SIC #

20	3.800	0	3.572	0	0	0	4.056	5.052	.098	0
21	0	0	0	0	0	0	0	0	0	0
22	4.157	0	4.379	0	0	0	3.181	7.927	.361	0
23	.849	0	.239	0	0	0	.223	.188	.064	0
24	1.162	0	.217	0	0	0	1.333	.864	.137	0
25	.538	0	.103	0	0	0	.608	.489	.851	0
26	11.549	0	1.976	0	0	0	39.033	49.225	2.167	0
27	1.938	0	.871	0	0	0	.875	.287	1.047	0
28	3.637	0	3.007	0	0	0	2.415	14.352	.615	0
29	.279	0	.069	0	0	0	.789	.286	.013	0
30	5.395	0	1.478	0	0	0	2.206	4.310	.352	0
31	1.047	0	.102	0	0	0	.791	.997	.081	0
32	2.677	0	5.174	0	0	0	4.059	4.708	.204	0
33	4.795	0	6.668	0	0	0	3.091	4.244	.040	0
34	6.017	0	6.365	0	0	0	3.761	4.819	.381	0
35	5.965	0	3.229	0	0	0	3.014	3.333	.028	0
36	5.540	0	2.424	0	0	0	2.875	2.760	.052	0
37	4.325	0	2.153	0	0	0	1.691	4.227	.014	0
38	2.029	0	1.640	0	0	0	1.295	1.640	.006	0
39	2.592	0	1.128	0	0	0	1.309	1.578	.068	0

* These two figures represent the total electrical energy produced from these energy sources (implied efficiency of 1.0). In the computer simulation and in the output, these will be lumped together into 73.50 of "Nuclear" capacity, which is allocated to users before other electricity is generated.

Modifications to
the NEME Model

New England Macroeconomic Energy Model

Documentation On:

Total Energy Quantity Price Response

Philip C. Abbott

August 5, 1977

An additional function has been added to the New England Macroeconomic Energy Model to simulate sectoral energy conservation in response to an increase in that sector's real energy price index. This function is very similar to one used by Baughman and Zerhoot, Nissen and Knapp, and the FEA PIES model. While fuel-switching will still be handled by the energy-use coefficient adjustment parameters, this new function causes total energy use per unit of sectoral output to respond to the energy price index for that sector (PE_{it}). These indices are identical to those constructed previously for use-coefficient adjustments; using the notation of the Task I: Final Report for this project, * the equations describing the indices are still given as:

$$PE_{it} = \left(\sum_{k=1}^{10} PI_{kt} B_{ki,t-1} \cdot UPRF_{kit} \right) / \left(\sum_{k=1}^{10} B_{ki,t-1} \right)$$

where:

- PI_{kt} is the price for primary product k at time t that would apply to the manufacturing sector
- $UPRF_{kit}$ is the factor adjusting the price of primary product k to industry i at time t
- B_{kit} is the primary product use coefficient : the requirement of primary product k per unit of output of sector i as of time t.

Now, TEQ_{it} is intended to be a total-energy-use index (per unit of output) for sector i at time t, and it is constructed using a simple lag-adjustment formula.

* see pages 5-11 for a complete notational description of that report.

$$TEQ_{it} = TEQ_{i,t-1} \cdot DEL_i + (1-DEL_i) \left(\frac{PE_{it}}{PE_{i0}} \right)^{DEE_i}$$

where:

TEQ_{it} is the total-energy-use index for sector i at time t

DEL_i is the lag term for industry i (between 0 and 1)

PE_{it} is the total-energy-price index for sector i at time t

DEE_i is the total-energy price-response elasticity for sector i

It should be noted that TEQ_{i0} equals one arbitrarily, and PE_{i0} is also equal to one using the conventions established in the model program.

This newly constructed total-energy-use index (TEQ_i) is then used to readjust the energy-use coefficients in the following manner:

$$B_{kit} = \left[LA_{ki} \cdot B_{ki,t-1} + GA_{ki} \left(\frac{PI_{kt} \cdot UPRF_{kit}}{PE_{it}} \right)^{AP_{ki}} \right] (1-DE_{it}) \cdot TEQ_{it}$$

where: This adjusting equation is used for $k=1-10$

LA_{ki} is a simple lag-fraction for primary product k in industry i

GA_{ki} is a constant term for primary product k in industry i

AP_{ki} is the price elasticity of adjustment for energy k in industry i

DE_{it} is a simple conservation fraction for industry i at time t

While the model's implementing program operates in a slightly different fashion than the above procedures (an energy-use index is never actually created within the program), the results are identical to what would be obtained if the above procedure were used.

In order to implement this function, three new sets of inputs are required: DEE_i , DEL_i , and indicators telling the program whether or not to implement this function. Referring to Table 26 of the Task I: Final Report, these inputs should follow immediately after the Use-Coefficient Adjustment Parameter* and precede the Aggregate I-0 Table Intermediate Requirements.

Total Energy Quantity Price Response

DEE_i , $i=1-6$ (1x7, elasticity values)

TEQPR Lags

DEL_i , $i=1-7$ (1x7, lag fractions)

TEQPR Use Indicator

DES_i , $i=1-7$ (1x7, enter 0 or 1; 0 indicates this function is to be omitted for sector i)

The proper elasticities and lag terms would be identical to those used in the sources mentioned above; but care should be taken to insure that the implicit period of adjustment corresponds to the simulation period of this model.

* see page 43 for clarification.

Electricity Rate Determination

The energy planning model has been revised to incorporate the inclusion of a fixed capital cost as part of the electricity rate and to allow a more direct interpretation of parameters in the electricity supply specification. That is, the model now allows fixed total capital costs (which do not depend on the actual amount of electricity produced) to be included as part of the costs to be averaged in the model's rate setting procedure. The variable FEC_t equals this total fixed cost charged per year in determining the electric rate. This procedure is in addition to possibility of including capital rental costs which are proportional to the value of electricity produced (which was formerly the sole procedure for charging capital costs in the rate setting procedure). This capital rental cost is specified by the variables V_{7t} and W_{7t} , as before.

This addition means that the electricity supply equation in the Task I Final Report now appears in the model as follows:

$$PI_{1t} = \frac{(\sum_{k=2}^{10} B_{k7t} \cdot PI_{kt} \cdot UPRF_{7kt} (Y_{1t} - Y_{2t})) + B_{117t} \cdot PI_{11t} \cdot RW_{7t} \cdot Y_{1t} + PI_{2t} \cdot Y_{2t} + FEC_t}{(\sum_{i=1}^7 X_{it} \cdot B_{1it} \cdot UPRF_{i1t}) (1 - W_{2t} U_{7t})}$$

This equation is simply a rearrangement of an accounting identity for the electric sector which sets income equal to costs.

Since this rate setting procedure is based on a straightforward accounting of costs in the electric sector, the basis for rate setting will be of interest in analyzing model outcomes. That accounting of incomes and costs is provided with each year's solution the model produces. Table 1 presents such an output for the 1974 base New England data, along with explanations of elements on the Table.

Table 1

1974 - New England
ELECTRICITY COSTS AND REVENUES - CURRENT DOLLARS

ITEM	TOTAL ¹	PER UNIT ²
ENERGY COST	953.8787	1.4321
LABOR COST	257.5637	0.3867
FIXED COST	1068.7000	1.6045
VARIABLE COST	139.0383	0.2088
REVENUE ³	2419.1807	3.6321
AMC-REV	0.0	2.8103
MAN-REV	562.2744	2.8103
COMTR-REV	0.0	2.8103
SER-REV	804.8103	3.9259
RESTR-REV	0.0	2.8103
RESENER-REV	1051.8757	4.0316

1. In millions of 1974 dollars or current dollars (as specified in Table title).
2. In ¢ per kilowatt hour, either in 1974 dollars or current dollars.
3. Equal to the sum of costs incurred by the electric sector as well as the total income to the sector.

Projections and Policy Analysis

Scenarios

1. Inputs
2. Results

Simulation Inputs

Projections and Policy Analysis Scenarios - Inputs

In order to analyze energy policy alternatives, a projection scenarios predicting energy usage patterns and the underlying economic structure was produced which yielded projections similar to those of the FEA PIES model. This model requires a basic economic projection in order to make its forecasts, and those were prepared for the most part by Mr. Zeitz and Mr. Lutostanski of the Energy Office. Those economic projections include the growth of aggregate demand levels for New England to 1980 and 1985, as well as energy prices to be charged by suppliers to the various end users. Several demographic variables were also projected. These projections are presented in Tables 5, 6, 7, and 8.

The economic projections represent a reasonably optimistic forecast of New England's economic future. The 3.746% growth rate for regional income to 1980 and the 3.5% growth rate to 1985 are on the high side of expectations by regional economists, though they are consistent with the U.S. growth rate projections of Data Resources, Inc. The assumed labor force participation rates and growth in labor productivity consistent with the regional income growth rate will yield a low but reasonable unemployment rate for the region of about 5.5%. These economic projections will be used throughout, so they will provide a reasonable basis for comparison of policy alternatives, in spite of their optimistic nature. It should be noted that the Data Resources, Inc. projections, mentioned above, and the projections of the Massachusetts Econometric Model (Treyz, et al, 1977) have provided the basic economic information used in preparing these projections. The price projections used are based on FEA inputs to the PIES model, since that model is well suited to the estimation of energy supply behavior, and our estimates of quantities supplied to the region are very close to the PIES projections.

Each of the policy analysis scenarios to be considered are modifications of this base run. Several scenarios have been produced for each of the areas of consideration mentioned earlier, and those modifications are described below.

1. Effects of Price Induced Conservation

To test the effects of price-induced conservation the Total Energy Conservation Price response mechanism was activated. In this case price changes will induce conservation, as well as fuel switching (as in the base case). The elasticity parameters used are presented in Table 9. This projection scenario has been labelled Nebase.

It should be noted that the price conservation mechanism is not operative during conservation simulations. Further, the elasticity terms used are always uncertain. The estimates shown in Table 9 were prepared by FEA and are national rather than specific for New England.

Table 5

Basic Economic Projections and Implied Growth Rates (per annum, continuously compounded)

Variable (units)	1974	74-80 Growth Rate	1980	80-85 Growth Rate	1985
U.S. Nominal GNP (billions \$)	1406.83	9.881%	2545.17	8.500%	3893.07
U.S. GNP deflator	1.000	6.135%	1.445	5.000%	1.855
U.S. Real GNP (billions '74 \$)	1406.83	3.746%	1761.4	3.500%	2098.7
U.E. population (millions)	12.15	0.790%	12.74	0.800%	13.26
U.E. labor force part. rate	.4538	0.900%	.4790	0.819%	.4990
U.E. labor force	5.514	1.689%	6.102	1.620%	6.617
U.E. Wages					
(current \$/hr.)	4.10	7.634%	6.482	6.500%	8.971
('74 \$/hr.)	4.10	1.500%	4.486	1.500%	4.836
U.E. Disp. Income (GRP)					
(millions current \$)	77006	9.635%	137275	8.500%	209974
(millions '74 \$)	77006	3.500%	95000	3.500%	113193
H-E-M (sector demand levels in current \$ millions)					
Agr. Min. Constr.	2801.32	9.835%	5054.05	8.500%	7730.63
Manufacturing	3533.0	9.835%	6374.13	8.500%	9749.81
Comm. Trans.	342.4	9.835%	617.75	8.500%	944.90
Comm. Services	10692.3	9.835%	19290.7	8.500%	29506.87
Resid. Trans.	0	--	0	--	0
Resid. Ener. Serv.	0	--	0	--	0
Other Employment (in millions)	1.230	1.500%	1.346	1.500%	1.451
Vehicles per capita	.5772	1.700%	.6392	1.700%	.6959
Vehicles (in millions)	7.013	2.500%	8.143	2.500%	9.228
Dwellings per capita	.3235	.600%	.3353	.600%	.3455
Dwellings (in millions)	3.930	1.391%	4.272	1.400%	4.581
Aggregate Relative Sectional Wage Factors (wage in sector/wage in region) ⁻¹					
Agr. Min. Constr.	.8499	1.500%	.7767	1.500%	.7206
Manufacturing	.8509	1.500%	.7777	1.500%	.7215
Comm. Trans.	.8595	1.500%	.7855	1.500%	.7288
Comm. Services	1.1375	1.500%	1.0396	1.500%	.9645
Resid. Trans.	1.0	1.500%	.9139	1.500%	.8479
Resid. Ener. Serv.	1.0	1.500%	.9139	1.500%	.8479
Electric	.63667	1.500%	.58187	1.500%	.53983

.53983

Table 6

Energy Prices to the Manufacturing Sector Used in Projections

Energy Forms	Units	1974	Basic FEA Projection		Carter Energy Plan	
			1980	1985	1980	1985
(i n c u r r e n t d o l l a r s)						
Electricity	(¢/kwh)	2.8100	4.543	6.31	4.797	6.469
Nuclear	(¢/kwh)	0.212	0.306	0.393	0.306	0.393
Natural Gas	(\$/mcf)	2.620	3.786	4.86	3.815	4.910
LPG	(\$/barrel)	9.068	16.39	22.53	19.00	26.82
Gasoline	(¢/gallon)	35.23	73.724	103.68	77.076	109.40
Kerosene	(¢/gallon)	34.961	57.323	79.95	59.996	84.74
Distillate	(¢/gallon)	32.50	53.382	72.04	59.996	84.74
Residual	(\$/barrel)	12.43	20.933	27.241	20.983	31.592
Coal	(\$/short ton)	25.15	48.39	65.00	45.00	67.64
Exotic	(\$/BTU)	0	0	0	0	0
(i n c o n s t a n t ' 7 4 d o l l a r s)						
Electricity	(¢/kwh)	2.8100	3.144	3.402	3.320	3.487
Nuclear	(¢/kwh)	0.212	0.212	0.212	0.212	0.212
Natural Gas	(\$/mcf)	2.620	2.620	2.620	2.640	2.647
LPG	(\$/barrel)	9.068	11.343	12.145	13.149	14.458
Gasoline	(¢/gallon)	35.23	51.020	55.892	53.340	58.976
Kerosene	(¢/gallon)	34.961	39.700	43.100	41.520	45.682
Distillate	(¢/gallon)	32.50	36.943	38.836	41.520	45.682
Residual	(\$/barrel)	12.43	14.521	14.685	14.521	17.031
Coal	(\$/short ton)	25.15	33.488	35.040	31.142	36.464
Exotic	(\$/BTU)	0	0	0	0	0

Table 7

1974 Energy Prices To Manufacturing - Basic FEA Projection
(in \$/million BTU's)

Energy Forms	\$/million BTU's	Heat Content
		Conversion Factors
Electricity	8.2356	3412 BTU's per KWH
Nuclear	0.6213	3412 BTU's per KWH
Natural Gas	2.5915	1011 BTU's per cubic foot
LPG	2.2619	4.009 million BTU's per barrel
Gasoline	2.8195	5.248 million BTU's per barrel *
Kerosene	2.5897	5.670 million BTU's per barrel *
Distillate	2.3433	5.825 million BTU's per barrel *
Residual	1.9771	6.287 million BTU's per barrel
Coal	1.10307	22.80 million BTU's per short ton
Exotic	0	

* 42 gallons per barrel

Table 8

Factors Adjusting Different Energy Prices to Different Users
 (Energy Price to Sector / Energy Price to Manufacturing)

R e l a t i v e P r i c e t o S e c t o r

Energy Form	Agr., Min., Const.	Comm. Trans.	Services	Res. Trans.	Res. En. Serv.	Elect.
	(H i s t o r i c a l 1 9 7 4)					
Electricity	1	1	1.3970	1	1.4346	1
Nuclear	1	1	1	1	1	1
Natural Gas	1	1	1.2889	1	0.8981	.3817
LPG	1	1	1	1	1	1
Gasoline	1	1.1660	1	1.1660	1	1
Kerosene	1	1	1	1	1	1
Distillate	1	1.0311	1.0005	1	1.0953	0.9613
Residual	1	1	1.0999	1	1	0.9203
Coal	1	1	1	1	1	1
Exotic	1	1	1	1	1	1

(w i t h B a s i c F E A p r i c e p r o j e c t i o n s)

Electricity	1	1	1.17	1	1.778	1
Nuclear	1	1	1	1	1	1
Natural Gas	1	1	1.053	1	1.256	1
LPG	1	1	1	1	1	1
Gasoline	1	1.0619	1.0619	1.0619	1	1
Kerosene	1	1	1	1	1	1
Distillate	1	1	1	1	1.068	0.885
Residual	1	1	0.981	1	1	0.92
Coal	1	1	1	1	1	0.873
Exotic	1	1	1	1	1	1

(w i t h C a r t e r ' s e n e r g y p r o g r a m)

Electricity	1	1	1.171	1	1.178	1
Nuclear	1	1	1	1	1	1
Natural Gas	1	1	1.055	1	1.259	1
LPG	1	1	1	1	0.965	1
Gasoline	1	1.07	1.07	1.07	1	1
Kerosene	1	1	1	1	1	1
Distillate	1	1	0.9058	1.175	0.9139	0.877
Residual	1	1	0.869	1	1	0.901
Coal	1	1	1	1	1	0.851
Exotic	1	1	1	1	1	1

Table 9

FEA Users Coefficient Adjustment Parameters¹Adjusted for 5-6 year periods
Residential Sector

	<u>Price Coefficient</u>	<u>Lag Term</u>
Total Energy	- .416	.149
Electricity	- 1.043	.431
Natural Gas	- .853	.452
LPG	- .627	.0032
Kerosene	- .689	.364
Distillate	- .931	.021

Commercial Sector

	<u>Price Coefficient</u>	<u>Lag Term</u>
Total Energy	- .292	.022
Electricity	- .598	.0032
Natural Gas	- .441	0
Distillate	- .639	0
Residual	- .639	0

Industrial

	<u>Price Coefficient</u>	<u>Lag Term</u>
Total Energy	- .293	.041
Electricity	- .688	.396
Natural Gas	- .562	.128
LPG	- .694	.079
Kerosene	- .694	.079
Distillate	- .694	.079
Residual	- .439	0
Coal	- .789	.0037

¹ These parameters were used in the base projection, with the exception of the total energy price elasticities, which were only used in the Carter projections. The total energy parameters are the ones which were "activated" for the Carter and Nebase projection cases.

2. Effects of Alternative Electric Generation Scenarios

At this point, two alternatives have been simulated - low nuclear construction - only one new nuclear facility is added before 1985 and - an examination of the consequences of increased coal utilization by the electric sector. In the coal simulation, the energy use coefficients for the electric sector are altered so that more coal is used. The coal coefficient becomes 0.77652 BTU's used per BTU of electricity produced, and the use of residual oil is reduced to 2.4381 BTU's per BTU out. In addition, the fixed cost charge on the electric rate is increased to \$1.688 billion in 1980 and \$3.956 billion in 1985 to reflect costs of this charge. This simulation is labelled Coal 2.

The low nuclear simulation requires a reduction of the fixed cost charge for 1985 to \$2.255 billion, and a reduction in the amount of nuclear power generated, corresponding to the removal of four plants - (106.8 v 197 10^{12} BTU). This simulation is labelled LONUK.

3. Energy Conservation Investments

Energy conservation investments in the industrial sector, service sector and residential sector have been examined independently. Two simulations have been produced for the industrial sector, and nine for the service sector and two for the residential sector. These simulations investigate the effect of different levels of conservation investment and different assumptions about the actual costs of those investments and their consequence effects on prices.

Investments yielding energy use reductions of 10%, 20%, and 30% per unit produced have been considered for the service sector, and this charge has been captured through use of the conservation term for the service sector in the model. It is also assumed that these investments are half-completed by 1980 and fully completed by 1985. One cost assumption which is made is that these conservation levels are achieved at no additional cost to the firm. The other assumption is that an investment achieving a 10% reduction will pay itself back in 2 years, a 20% reduction in 4 years, and a 30% reduction in 6 years. Two assumptions are made on how these costs are charged on the prices charged by the service sector. One is that these capital investments are charged at a 5% rental rate (real), corresponding to our estimate of the real cost of capital in the economy; and the other is that a 12% rental rate is charged, corresponding to the average internal rate of return on capital achieved by industry in the U.S. These cost charges are captured in the model by alteration of the capital income adjustment terms. Simulation labels and the specific changes entered are presented on Table 10.

Only one conservation level in the industrial sector is assumed, corresponding to a 16% reduction in energy use per unit produced by 1985. It is also assumed that these conservation investments are completed by only half of the industrial firms by 1980. This estimate corresponds to the FEA expectation for industries in the U.S. by 1985. Again, two assumptions are made on the cost of these investments. One, the FEA assumption, is that these investments will be paid back by energy savings in 4 years, and these investment costs will be charged on the price of sector output using a 12% rental rate, corresponding to the average U.S. internal rate of return for industries. The simulation labels and data changes for these two cases are also presented in Table 10.

Two conservation levels were considered in residential sector - 20% and 30%, roughly corresponding to Case I and Case II of the residential conservation report. The model has no provision for charging the cost of conservation measures to the residential sector. Therefore, the macro impacts will be estimated using the resultant effect on disposable income.

Table 10

Data Changes for Conservation SimulationsCommercial (Service Sector) Conservation

Simulation Label	Conservation Term - Sector 4		Capital Income Adjustment Term	
	<u>1980</u>	<u>1985</u>	<u>1980</u>	<u>1985</u>
Free 10	0.05	0.053	1.0	1.0
Free 20	0.10	0.108	1.0	1.0
Free 30	0.15	0.175	1.0	1.0
Con 10	0.05	0.053	1.000390	1.000781
Con 20	0.10	0.108	1.00156	1.00312
Con 30	0.15	0.175	1.00351	1.00703
Con 12	0.05	0.053	1.000937	1.001874
Con 22	0.10	0.108	1.00375	1.007494
Con 32	0.15	0.175	1.00843	1.01686

Industrial Conservation

Simulation Label	Conservation Term - Sector 2		Capital Income Adjustment Term	
	<u>1980</u>	<u>1985</u>	<u>1980</u>	<u>1985</u>
Ind 1 F	0.0818	0.0891	1.0	1.0
Ind 1	0.0818	0.0891	1.004398	1.008797

Residential Conservation

	Conservation Term - Sector 6	
	<u>1980</u>	<u>1985</u>
Res 20	.095	.095
Res 30	.14	.14

Table 11

Data Changes for Aggregate Demand Sensitivity Simulations

<u>Simulation Label</u>	<u>GRP</u>	<u>G+ E - M for Sector:</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
<u>1980</u>					
Combined Income and External Demand Changes					
GRP + 1 W	138648.	5104.5	6437.8	623.9	19483.6
GRP - 1 W	135902.	5003.5	6310.4	611.6	19097.8
GRP + 5 W	144139.	5306.7	6692.8	648.6	20255.2
GRP - 5 W	130411.	4801.3	6055.4	586.9	18326.2
Income Changes Only					
GRP + 1 WO	138648.	NC	NC	NC	NC
GRP - 1 WO	135902.	NC	NC	NC	NC
GRP + 5 WO	144139.	NC	NC	NC	NC
GRP - 5 WO	130411.	NC	NC	NC	NC
External Demand Changes Only					
GEM + 1 M	NC	NC	6437.8	NC	NC
GEM + 1 S	NC	NC	NC	NC	19483.6
<u>1985</u>					
Combined Income and External Demand Changes					
GRP + 1 W	212074.	7807.9	9845.3	954.3	29802.0
GRP - 1 W	207874.	7653.3	9650.3	935.5	29211.8
GRP + 5 W	220473.	8117.1	10235.2	992.1	30982.2
GRP - 5 W	199475.	7344.1	9260.4	897.7	28031.6
Income Changes Only					
GRP + 1 WO	212074.	NC	NC	NC	NC
GRP - 1 WO	207874.	NC	NC	NC	NC
GRP + 5 WO	220473.	NC	NC	NC	NC
GRP - 5 WO	199475	NC	NC	NC	NC
External Demand Changes Only					
GEM + 1 M	NC	NC	9845.3	NC	NC
GEM + 1 S	NC	NC	NC	NC	29802.9

NC = No Change

All numbers are reported in millions of current dollars.

4. Sensitivity to Aggregate Demand Levels

Since this model is demand-driven and numerous demand levels may be exogenous to the model, but not to the economy, it is of interest to see how sensitive results are to changes in aggregate demand levels. Terms to be altered, therefore, are Gross Regional Income (GRP) and external demand levels ($G + E - M$) for each of the four sectors. Many combinations of changes for these variables are possible, and a limited set have been chosen to illustrate the effect of some of the possibilities. It was decided that both 5% and 1% changes in demand levels were desirable to determine if the effects of demand changes were more or less linear (proportional to income changes). Both positive and negative deviations were simulated, as well. In one set of simulations, the above deviations were used for both gross regional income and external demand for all sectors (and in the same proportion for each demand level). These were intended to simulate

the effects of slower or faster balanced economic growth for the region. Changes in only gross regional income were simulated in order to assess the importance of that variable as compared to the importance of external demand variables. Also, 1% increases in external demand for the service and manufacturing sectors were considered separately, in order to gain additional insight into the importance of external demand changes, and especially to consider the consequences of additional demand for the product of these sectors which is likely to come about if conservation investments discussed above are implemented.

The data used to implement the ten simulations indicated above are presented in Table 11. Simulation labels are also indicated on that table.

Simulation Results

Projection and Policy Analysis Scenarios - Results

Each of the simulations indicated above have been run on the computer, and outputs have been provided to the Massachusetts Energy Policy Office. In this section, observations on the nature and indications of the results obtained will be presented for each of the areas of consideration.

1. Projection of New England's Energy Needs and the Underlying Economic Structure.

Some time has been spent preparing a reasonable set of economic projections for the region and attempting to insure that energy use projections line up with the supply forecasts of the FEA PIES model. This has been achieved and an interesting projection has resulted, in which a couple of indications of possible errors in the FEA forecast have emerged.

This base projection indicates energy use in New England is likely to grow at a rate of 2.86% per year from 1974 to 1985 if income grows at 3.5% per year. Energy use growth is somewhat faster to 1980 (3.90% per year), and slows to 1.7% per year from 1980 to 1985. This is in part due to the substantial increase in electricity generated by nuclear energy and the way nuclear energy is accounted in the model. Nuclear energy is measured as an output, equal to the electricity generated and replaces other energy forms included as inputs which are utilized at about a 30-35% efficiency rate. Also, nuclear energy only grows 2.03% per year to 1980 and 9.4% to 1985. Most other energy forms are growing at about 2% per year both to 1980 and to 1985 with a 3.5% growth in final demand. The notable exception is demand for electricity, which grows at 5.77% to 1980 and 4.77% to 1985. This is largely because a 2% per year exogenous increase in electric use by the manufacturing and service sector is assumed by the model. This exogenous growth in electricity demand by these sectors is probably exaggerated, since the real electricity rate is growing at 1.63% per year to 1985, and this is greater than the increase for some other fuels, and is not substantially smaller than the increase in price for petroleum products, which is about 4% per year.

These increases in energy use and price combined imply an increase in real energy costs for the economy of 6.32% to 1980 and 4.73% to 1985 - a fairly substantial effect. The consequence of this is real price increases in all sectors, and an average real price increase for the New England economy of 5.92% in 1980 and 10.02% in 1985. This is led by a 13% increase (cumulative) in transportation costs to the residential sector and an 18.5% increase for other energy uses by households. The smallest price increase is in the service sector, amounting to 7.9%. This means the future energy problems New England faces are likely to put further pressure on the shift to an economy dependent on the provision of services rather than the production of manufactured goods. Obviously, the dependence of other regions in the U.S. on energy may modify this result, but direct demand effects within the region suggest an increase in final demand (in quantity) for services at 3.7% per year to 1985, and of 3.0% per year to 1985 for the manufacturing sector.

These shifts in demand and price changes are why energy use for the service sector grows at 4.88% per year to 1980 and 4.31% to 1985, while growth in the manufacturing sector is 3.56% to 1980 and 3.39% to 1985, with an exogenous 2% per year increase in electricity use. The exogenous increase in electricity use is also why energy use per unit produced increases in these two sectors (4% in manufacturing and 6.75% in services), and decreases in all other sectors. The use of more efficient cars, in fact, implies a 22.8% decline in energy use per miles travelled for residential

transportation. Price-induced conservation in this simulation is slight (0.8%) for other residential energy use, but then the total energy conservation price mechanism is not operating in this projection for any sector.

The mechanism allowing switching of energy forms used in production is operating, however, for the manufacturing, service, and residential sectors. As a result, use per unit for coal falls in all sectors and use per unit of natural gas rises in manufacturing and services, but it falls in the residential sector by 11%. Surprisingly, petroleum use remains pretty much unchanged in all sectors, indicating that prices for petroleum are really not increasing faster than the average of other energy forms to an extent sufficient to discourage petroleum use (if our assumed behaviors are correct). This points to the crucial nature of relative price projections and the projected behaviors in response to those prices. As a result, the import bill to the economy for energy as predicted by our crude supply estimations (an assumption that domestic availability to the region is fixed) grows at 14% per year to 1980 and at 10% per year to 1985 - a very substantial increase.

In this base simulation, labor costs are growing at 4.87% per year, led by a 5.27% per year growth in the service sector. With a 1.5% per year growth in labor productivity, this means an unemployment rate of 5.77% in 1985 and 6.32% in 1980. Regionally generated income is growing at 4.18% per year, as growth in value added contributions from capital and taxes are growing at about the economic growth rate of 3.5% per year, and labor income is growing faster. These are a consequence of the optimistic economic projection, and if slower growth is projected, substantial increases in unemployment will come about.

2. Effects of Price Induced Conservation

The Nebase simulation indicates that if price-induced conservation actually occurs, reductions in energy use and improvements in the economy do occur. Total energy use declines 5.91% in 1980 and 10.72% in 1985 (below the base projection). This is as a result of substantial declines in gasoline use - 11.4% in 1980 and 24% in 1985, and declines in other petroleum uses of about 5% in 1980 and 7 to 9% in 1985. With this mechanism, the use of all energy forms declines in use per unit produced. This conservation amounts to about 5% in manufacturing and services, 6.33% in the residential sector, 22% in residential transportation, and 32% in commercial transportation.

The conservation per unit achieved through this mechanism is dampered somewhat by a reduction in energy costs in the region of 11.33% in 1985 and 6.12 in 1980, leading to lower price increases in all sectors than the base projections suggest. The average real sectoral price increase is 0.72% less in 1980 and 1.27% less in 1985 as a result of this energy substitution, and prices of energy in 1985 to households decline 22.09% for transportation services and 6.82% for other energy services. This is simply due to the fact that conservation implies the same services are provided for a lower energy input. The cost advantage to the service sector is also reduced, as the price for services declines 0.32% while the price for manufacturing declines 0.59% from the base projection.

The indicated price reductions bring about slight increases in production levels, amounting to a total production 0.09% higher than in the base projection. This reduces the unemployment rate by 0.02% to 6.30% in 1980, and by 0.02% to 5.75% in 1985. Obviously, by allowing the economy to adjust more fully to the projected energy price increases, improved economic outcomes are achieved. The resulting improvement in regionally generated income is 0.05% in 1980 and 0.08% in 1985. This improved economic projection is the one which should be compared to the projections under the Carter Program, as it includes the same underlying economic structure as is used in those projections.

3. Effect of Alternative Electric Generation Scenarios

As mentioned earlier, this section is concerned with regulations requiring electric utilities in New England to shift certain power plants to coal-burning facilities. One simulation, which assumes a substantial shift to coal, has been run. That simulation assumes changes in the input mix for fossil fuel-generated electricity, and the capital costs associated with such conversion. This simulation was then compared to the base case in order to determine not only the effects of this regulation on the electric rate, but also examine its economic ramifications.

The simulation run indicates similar results for 1980 and 1985. In 1980, switching to coal reduces fuel costs by 5.24% in total, and 6.15% per kilowatt-hour produced. In 1985, fuel costs are reduced by 5.15% in total and 5.40% per kilowatt-hour. The conversion capital costs increase the fixed charge per kilowatt-hour 0.78% in 1980 and 3.37% in 1985. These cause reductions in the electricity rate amounting to 10.5¢ per kilowatt-hour or 2.90% in 1980 and 0.43¢ in 1985. The substantial difference in rate reductions is due to the substantial amount of electricity generated by nuclear energy in 1985. Nuclear capacity increases from 25% of total electricity produced in 1980 to 52% in 1985. Coal utilization by the electric sector, with conversion, drops by 134.4 trillion BTU's from 1980 to 1985, which amounts to 23% of 1980 coal use.

The primary effect of these rate reductions is to stimulate electricity use and reduce costs to the economy. Aggregate electricity demand increases 0.96% in 1980 and 0.27% in 1985, over the base projection, at these lower rates. This is caused by an increased demand for coal of 141% in 1980 and 133% in 1985, entirely due to the increased electric demand. Since this coal substitutes for more expensive residual oil, the demand for residual oil declines 10% in 1980 and 8.46% in 1985. The lower electric rate means total energy costs to the economy decline 1.48% in 1980 and 0.47% in 1985. These in turn reduce prices by 0.1% or the average in 1980 and leave 1985 prices virtually unaltered.

With such small price effects - due to the assumption that supply prices for coal and oil are perfectly elastic - then virtually no general equilibrium or spin-off effects result from this conversion. There is little fuel switching on the part of producers, and few price-induced consumption effects occur. This probably indicates that such an assumption is crucial, rather than indicating the true nature of such results.

The conclusions to be drawn from these results is that coal conversion would be economically beneficial in 1980, and would be a break even proposition in 1985 as less expensive nuclear energy became more available. Hence, if the fixed charge is based on an expectation that conversion costs can be written off by 1985, then conversion should proceed. On the other hand, if capital costs are to be written off over a much longer time, or if the price of residual oil rises more slowly than is anticipated here, then conversion of some electric plants to coal burning facilities may add costs to society on top of already existing energy problems.

The low nuclear simulation results in a 7.6% reduction in the cost electricity - an average of .28¢ per kwh, in 1985. There were no changes to the inputs for 1980, hence results are for 1985. This price reduction is sufficient to stimulate fuel switching in favor of electricity. Electric demand increases 2.45% while demand for Natural Gas and Distillate falls 1.19% and 1.76% respectively.

The reduced electric price results in a slightly lower cost of living, - .28%. Residential energy costs, however, are reduced 3.54%. Slight increases in production are stimulated by these price decreases (-.23% in manufacturing and -.17% in services).

Though manufacturing and commercial uses of residual fuel are reduced by slightly less than 2%, the electric sector now burns significantly increased amounts of residual oil to substitute for the "missing" nuclear plants. This results in a net increase in residual consumption of 27.2% or 283×10^{12} BTU (utilities burn 292×10^{12} BTU or 46 million barrels more of residual fuel oil).

The effect on electric rates of the low nuclear simulation is particularly sensitive to the price of residual oil. However, under current projections of residual oil prices lower nuclear construction would result in lower electric rates. This seems fortunate since current expectations regarding nuclear plant construction are more similar to the low nuclear case than the base case.

4. Energy Conservation Investments Commercial (service sector) Conservation.

Nine simulations representing conservation action by the service sector in New England have been run. These include combinations of three assumed levels of conservation (5%, 10%, and 15% in 1980 and twice those amounts in 1985) and three assumptions as to investment costs and the way those costs are passed on in prices of the service sector. Those assumptions are:

1. Conservation can be achieved at no cost to the sector, hence no capital costs are passed on to consumers.
2. Capital costs are charged at a 5% rate per year on prices.
3. Capital costs are charged at a 12% rate per year on prices.

The determination of costs for each level of conservation have been explained earlier.

When no change is made for capital costs, the primary effect of this action is to reduce energy use per unit produced by the amount of conservation specified above for the service sector. Since energy supply is assumed to be perfectly elastic, except for electricity and natural gas, all energy prices remain constant, except those two. Changes in those prices are extremely small, as well, being at most -4.89% for natural gas and +3.27% for electricity in 1985 when 30% conservation by the service sector is assumed. Hence, there is virtually no fuel switching by the service sector or other sectors in response to energy price shifts. For example, in the case cited above, deviations from 30% conservation are less than .015% for all fuels except electricity and natural gas, and in those two cases, deviations are only +0.87% and - 2.0% respectively. When the other extreme cost assumption is made, virtually identical results occur, as well.

The cost assumption also makes virtually no difference in total energy uses, either. That is, the energy savings indicated by these simulations are entirely due to the savings per unit produced for the service sector. Substantial energy savings are produced by this action, however. Table 12 summarizes the aggregate energy savings caused by commercial conservation. Table 13 documents the cost savings to the commercial sector associated with the indicated BTU savings. Since there are virtually no price effects, these results are very similar. These results also indicate the most striking savings are in use of distillate and residual oil, resulting in substantial savings in imports and import costs, as well.

The energy cost savings are sufficiently substantial to reduce prices charged by the service sector in all simulations. The indicated price changes for the service sector, and the effect these will have on average real prices for the economy are also presented in Table 13. These price changes only stimulate production increases in the service sector to any appreciable extent, and any employment gains associated with these conservation actions are in that sector. These effects are very small - on the order of 500 to 1000 jobs, but are always in the right direction. This is because conservation is a good investment, yielding a rate of return in excess of 12%. Hence, policies intended to stimulate this conservation are desirable though they should be unnecessary as it is in the best interest of service industries to adopt these measures on their own. The justification for these measures must be based on their own merits, rather than on economic spinoffs, such as increased jobs in the economy, however.

Table 12

Aggregate Energy Savings Resulting from Conservation in the
Commercial Sector

<u>Simulation</u>	<u>Percent Reduction in Total Demand for:</u>				
	<u>Energy</u>	<u>Electricity</u>	<u>Natural Gas</u>	<u>Distillate</u>	<u>Residual</u>
Free 10-1980	1.58	1.91	1.13	1.43	2.86
-1985	3.50	3.83	2.29	2.93	7.36
Free 20-1980	3.16	3.82	2.26	2.87	5.72
-1985	6.88	7.53	4.49	5.76	14.47
Free 30-1980	4.75	5.72	3.39	4.30	8.58
-1985	10.43	11.42	6.77	8.74	21.96
Con 10-1980	1.58	1.91	1.13	1.43	2.86
-1985	3.50	3.83	2.29	2.93	7.36
Con 20-1980	3.17	3.83	2.27	2.87	5.73
-1985	6.90	7.55	4.50	5.77	14.51
Con 30-1980	4.77	5.75	3.41	4.32	8.61
-1985	10.46	11.45	6.80	8.77	22.03
Con 12-1980	1.69	1.91	1.14	1.44	2.87
-1985	3.51	3.84	2.30	2.94	7.38
Con 22-1980	3.18	3.84	2.28	2.88	5.75
-1985	6.92	7.58	4.52	5.79	14.56
Con 32-1980	4.79	5.78	3.43	4.34	8.06
-1985	10.51	11.51	6.83	8.81	22.13

Table 13

Energy Cost Savings in the Commercial Sector
Due to Conservation and Consequential
Effects on Sector Prices

<u>Simulation</u>	<u>Percent Reduction in Energy Costs</u>	<u>Percent Reduction in Prices Charge by the Commercial Sector</u>	<u>Percent Reduction in Average Real Prices</u>
Free 10-1980	4.82	0.22	0.14
-1985	9.75	0.45	0.26
Free 20-1980	9.66	0.45	0.27
-1985	19.21	0.89	0.52
Free 30-1980	14.51	0.67	0.41
-1985	29.17	1.34	0.78
Con 10-1980	4.83	0.20	0.12
-1985	9.77	0.41	0.24
Con 20-1980	9.68	0.36	0.23
-1985	19.26	0.73	0.42
Con 30-1980	14.56	0.49	0.29
-1985	29.26	0.99	0.57
Con 12-1980	4.84	0.17	0.11
-1985	9.78	0.35	0.20
Con 22-1980	9.72	0.26	0.15
-1985	19.32	0.51	0.29
Con 32-1980	14.64	0.24	0.14
-1985	29.39	0.50	0.27

It should be noted, however, before leaving these results, that the assumption made was that aggregate nominal demand was held constant, so that such small price effects would have very small but positive consequences. The policies pursued may alter aggregate demand levels slightly, and the consequences of increased demand will be inflationary or expansionary depending on the existence of excess demand in the economy. The model structure used here is insufficient to address this question.

Industrial Conservation

Two simulations were run to examine the consequences of voluntary, non-price-induced conservation by the industrial sector. This simulation might also indicate the effects of a subsidy to induce such conservation, though no attempt has been made to account for a subsidy in either business costs or demand levels. One level of conservation (8.2% in 1980 and 16.4% in 1985) was assumed, and two cost assumptions were made. One cost assumption was that these conservation activities would require no investments by business, and the other was that the investments would be paid back by energy savings over four years, and the investment cost would be charged at 12% per year - the average internal rate of return for U.S. manufacturing industries.

The direct effect of this action is a reduction in energy use per unit produced in the manufacturing sector by amounts very similar to the overall conservation assumed. That is, adjustments in energy use due to energy price effects alter these conservation levels only slightly (less than 1%). This is because only the prices of electricity and natural gas are allowed to change, according to the model assumption, and those changes are +0.25% in 1980 and +0.72% in 1985 for electricity, and -0.79% in 1980 and -1.72% in 1985 for natural gas. With these small price changes, there is little switching in other sectors, as well.

The cost assumption also makes virtually no difference in energy use, and the entire energy savings for the economy in this simulation is due to saving in the manufacturing sector. Nevertheless, that savings is substantial - 1.62% in 1980 and 3.95% in 1985 for total energy use. Savings are particularly high for residual use (8.85% in 1985) since manufacturing industries are the principal user of that fuel, and electricity use is reduced 6.02% in 1985. This action would also reduce petroleum imports by 11.2% for residual oil and 5.3% for distillate in 1985.

The fuel cost saving for the manufacturing sector is \$128 million in 1980 and \$348 million in 1985, or 8% of energy costs for manufacturing in 1980 and 18% in 1985. When it is assumed that this conservation can be achieved costlessly, these savings will cause real prices in the manufacturing sector to fall 0.36% in 1980 and 0.79% in 1985. These savings are passed on somewhat to other sectors; particularly the agriculture, mining, and construction sector. Average real prices in the economy fall 0.14% in 1980 and 0.29% in 1985 simply from this conservation. When the charge as described earlier is introduced, prices still fall for the manufacturing sector - by 0.22% in 1980 and 0.60% in 1985. This means even at the assumed costs, conservation is still a profitable venture, yielding a rate of return well in excess of 12%. Consequently, average real prices for the economy fall 0.1% in 1980 and 0.22% in 1985 even with this assumption.

Since conservation by the manufacturing sector is a profitable venture, certain consequential economic benefits can be observed. Regionally generated income increases 0.04% in 1980 and 0.07% in 1985, with virtually all of the increase going to property income. Production in the manufacturing sector increases 0.03%, as well, creating 400 new jobs in that sector in 1980 and 1000 in 1985. This effect is too small to alter the overall unemployment rate by an observable amount, however.

The conclusions these results indicate are that energy conservation in the industrial sector would effectively reduce energy use in the economy by a substantial amount, and could be done in a profitable fashion. The other economic benefits are small, but in the right direction. Hence, a subsidy to stimulate this conservation would be appropriate if necessary, though it should not be required. A decision by industry not to conserve, according to the assumptions made here and the results they bring about, is irrational.

Residential Conservation

Residential conservation results in substantial reductions in yearly energy costs to the sector. The 20% case reduces energy costs by \$773.4 million. The 30% case reduces costs \$1100.8 million. From the residential conservation study, we estimate the yearly cost of these reductions are \$45.16 million and \$62.15 million respectively.

The net effect is increase disposable income by \$728.24 million in case I and \$1038.65 million in case II. This is a significant increase, nearly 1% of disposable income. The effects of this increase in disposable income was analyzed using the following sensitivity analysis. Thus, we estimate the additional demand created by this income will increase regional product .45% in the first case and .7% in the second case.

5. Sensitivity to Income and Demand Changes.

Since this model is based on an input-output structure with Leontief production functions, it is expected that changes in aggregate final demand will yield proportional changes in production, and consequently, proportional changes in primary product use. Since perfectly elastic energy supply is assumed, except for electricity and natural gas, most energy prices are fixed and so most product prices are also fixed. The adjustment mechanisms in the model matter only slightly, if at all, given these assumptions. With income elasticities not all equal to one, however, some shift in the structure of final demand will result, affecting the composition of production and particularly primary product uses. In this case, it is assumed that services have an income elasticity greater than one and manufacturing, an income elasticity less than one. With services using relatively less energy and labor than manufacturing, then the percentage changes expected for these would be less than for final demand.

Before comparing the results to these expectations, it is important to consider how much behavior is actually included in the model. Since this is a real sector model, demand does not depend on regionally generated income. Hence no multiplier mechanisms are operative. All simulations assume that government policy is pursued so that final demand is held constant, but this may not be the case; under Carter's ✓ Program, for example, much of the demand pulled out of the economy is replaced by government rebates. If perfect balance is not achieved, however, multiplier mechanisms will operate, and it is of interest to see what affect this will have on projection results. If the economic projections are overly optimistic, it is also of interest to see what consequences occur when lower demand levels are achieved. In any case, the level of final demand is a consequence of monetary and fiscal policy, and the solution to the problems those policies face should be solved independently of the problems posed by energy use and energy prices. That is, the economy should be driven to capacity regardless of the future energy problems will present.

The results of the income sensitivity simulations do in fact support the theoretical expectations. When all components of final demand are altered proportionally, a proportional change in production results. The important results are summarized in Table 14. When GRP and exogenous demand are changed by 1.00%, final demand changes 0.96% and production changes 0.93%. These slight reductions are simply due to the fact that Engle aggregation is not perfectly preserved by the model. Energy use changes of 0.77% are a result of a shift to more services, which uses energy less intensively than other sections in the economy. For example, in the simulation in which GRP and exogenous demand are increased 1%, final demands increase 1.09% for services, 0.84% for manufacturing, 0.20% for residential transportation, and 0.45% for residential energy services. Shifts in valued added towards higher property incomes and lower labor incomes are also a result of this shift in the composition of final demand. This shift also causes the changes in the energy use pattern as indicated by Table 14.

Table 14

Sensitivity to Income Changes
With Changes in Exogenous Demand (G+E-M)
 Proportional to Income Changes
 1985

Variable	Percentage Changes:			
	+ 1.00	+ 5.00	- 1.00	- 5.00
GRP*	0.95	4.74	- 0.96	- 4.74
Final Demand	0.93	4.63	- 0.93	- 4.63
Production Quantity	0.00	- 0.01	0.01	0.00
Prices	0.99	4.93	- 0.99	- 4.92
Value Added	1.02	5.05	- 1.02	- 5.04
Property Income	0.95	4.76	- 0.96	- 4.76
Labor Income	0.77	4.13	- 0.77	- 3.85
Energy Use	0.89	4.45	- 0.89	- 4.36
Electricity	0.52	2.62	- 0.52	- 2.77
Natural Gas	0.45	2.21	- 0.45	- 2.20
Gasoline	0.71	3.52	- 0.71	- 3.54
Distillate	1.44	7.18	- 1.44	- 5.54
Residual	1.71	8.49	- 1.71	- 5.70
Coal	-	-	-	-
Energy Prices	- 0.19	- 0.90	0.19	0.90
Electricity	0.35	1.72	- 0.35	- 1.83
Natural Gas				

*Altered exogenously

Several additional facts about these results should also be noted. First, the model is highly linear. That is, for 5% changes all results are very close to being simply 5 times the 1% changes. The only adjustment allowed which would prevent this from happening would be due to changes in electricity or natural gas prices. Since these changes are small, their consequences are virtually negligible. These adjustments are the only factors which could cause the effects of positive and negative changes in final demand not to have symmetric results. The extreme symmetry of the results, as Table 12 shows, illustrates the small effect these adjustments have. In addition, changes for 1980 and 1985 are virtually identical, so only results for 1985 have been reported.

Table 15, changes in GRP only are examined. The nature of these results is very similar to those when exogenous demand is also altered. The only important difference is that now the shift to a more (or less) service dominated economy is more pronounced. Final demand for services increases 0.84% with a 1% increase in GRP, while final demand for manufacturing only increases 0.64%. Otherwise, the same observations made above would apply in these cases, as well. Final demand increases by 0.72% per 1% increase in GRP, since not all of demand is increased. Production then increases 0.70% and energy use then increases 0.67%. Results are also highly linear and symmetric for positive or negative changes.

Table 16 presents simulation results illustrating the consequences of 1% changes in exogenous demand levels. Manufacturing and services are considered separately. It should first be noted that a 1% change in exogenous demand for manufactured goods yields a 0.05% change in final demand, while the same 1% change for services yields a 0.14% change in final demand. Manufacturing demand increases cause somewhat greater increases in production relative to the final demand increase than services demand increases. Increases in energy use, particularly for residual oil, are greater in percentage terms than the production increase for services, due to the shift in composition of final demand. In each case, however, the change in total energy use is less in percentage terms than the percentage change in production.

The conclusion to be drawn from these observations include:

1. It is safe to assume the model is linear, with proportional changes in production and sector activities arising from final demand changes, as long as energy supply is perfectly elastic.
2. The shifts in the composition in final demand cause energy use increases to be smaller in percentage terms than changes in production. Some shifts in the pattern of energy use does come about as a result of this, as well.
3. Positive and negative changes in final demand have symmetric effects.
4. The only price changes allowed are for electricity and natural gas, and these changes are sufficiently small that no changes in the real aggregate price level for the economy are observed.

Table 15

Sensitivity to Income Changes
Without Changes in Exogenous Demand (G+E-M)
 1985

<u>Variable</u>	<u>Percentage Changes:</u>			
GRP*	+ 1.00	+ 5.00	- 1.00	- 5.00
Final Demand	0.72	3.61	- 0.72	- 3.60
Manufacturing	0.66	3.26	- 0.66	- 3.30
Services	0.89	1.28	- 0.89	- 4.42
Production Quantity	0.70	3.48	- 0.70	- 3.48
Manufacturing	0.64	3.17	- 0.64	- 3.19
Services	0.84	4.22	- 0.84	- 4.19
Prices	- 0.00	- 0.01	0.00	0.01
Value Added	0.74	3.73	- 0.74	- 3.72
Property Income	0.77	3.84	- 0.77	- 3.82
Labor Income	0.72	3.58	- 0.72	- 3.58
Energy Use	0.67	3.35	- 0.67	- 3.14
Electricity	0.72	3.16	- 0.72	- 3.54
Natural Gas	0.43	2.17	- 0.43	- 2.32
Gasoline	0.36	1.81	- 0.37	- 1.83
Distillate	0.59	2.94	- 0.59	- 2.27
Residual	1.14	5.70	- 1.14	- 4.40
Coal	1.36	6.86	- 1.38	- 4.61
Energy Prices	-	-	-	-
Electricity	- 0.16	- 0.75	0.16	0.74
Natural Gas	0.29	1.43	- 0.29	- 1.53

*Altered exogenously

Table 16

Sensitivity in Income Changes
Changes in Exogenous Demand (G+E-M) Only
1985

<u>Variable</u>	<u>Percentage Changes:</u>	
G + E - M	0.20	0.61
Manufacturing*	+ 1.00	0.00
Services*	0.00	+ 1.00
Final Demand	0.05	0.14
Manufacturing	0.17	0.00
Services	0.00	0.26
Production Quantity	0.06	0.12
Manufacturing	0.13	0.03
Services	0.01	0.23
Prices	0.00	0.00
Value Added	0.05	0.15
Property Income	0.04	0.17
Labor Income	0.06	0.13
Energy Use	0.04	0.09
Electricity	0.05	0.10
Natural Gas	0.02	0.06
Gasoline	0.01	0.01
Distillate	0.02	0.07
Residual	0.07	0.19
Coal	0.10	0.18
Energy Prices	-	-
Electricity	- 0.01	- 0.02
Natural Gas	0.01	0.04

* Altered exogenously



New England Energy Policy Alternatives Study

Economic Impacts of Alternative Energy Policies

In A

Macroeconomic Model of New England

Appendix IV

Price-Induced Adjustments in Energy Use Patterns by New England
Industries and Households

May 1978

Massachusetts Energy Office
Henry Lee, Director

INTRODUCTION

The Massachusetts Energy Office is presently utilizing a macro-economic model of New England (NEME), designed and implemented by Abbott (1977) with the extensive cooperation of officials of that office, to assess the impact of alternative energy policies on energy use and economic outcomes in the region. The Massachusetts Energy Office is concerned with both the regional impact of President Carter's Energy Program and with its own initiatives intended to encourage energy conservation in the region. Such policies often rely heavily on taxes and subsidies, affecting the final prices paid by energy users, to induce conservation and cause energy use patterns to shift to more desirable energy sources. The NEME model is well-suited to the task of assessing the impact of such policies, since explicit price adjustment mechanisms are part of the model structure. Accurate policy assessment requires a strong empirical base for the parameters used to describe that adjustment, however. The projections of the model are no better than the assumptions on which they are based.

We believe that the empirical basis for the parameters presently used in NEME is weak. Estimation of such parameters using a regional data base and an improved model is desirable. Parameters presently being used in the NEME model are estimated from U.S. rather than regional data, and from a period prior to the 1973 energy crisis - when energy prices were relatively low and price variability was small. The relevance of that data base can be explicitly tested, and such tests are presented in this report. In addition, there has been considerable work outside the area directly considered by the Federal Energy Administration (1976) which is relevant to the estimation of these parameters. Also, the FEA (1976) study has been criticized by Hausman (1975) on the grounds that overly restrictive assumptions were used in the estimation procedure. We have attempted to incorporate the lessons from such work in our modelling and estimation procedures.

The final product of this report will then be improved estimates of the parameters required of the NEME model. The results will also provide some insights into the estimation problem and hopefully into the

formulation of price-based energy policies. An interpretation of the behaviors behind our results will be provided as well as exploratory evidence on some issues relevant to policymaking. Reprogramming of the NEME model in order to incorporate the important results of this study will also be suggested.

This report will begin carrying out these tasks by presenting a review of literature relevant to the models which are to be estimated. A discussion of the model chosen will then be presented, and the issues imbedded in the selected model or to be tested with alternative models will be examined. The estimation procedures used, along with the data used in that estimation, will then be reported, followed by the empirical results. An interpretation of those results which addresses specific issues will then be presented. The report will close with the conclusions which can be drawn from these results which are of interest to both energy policy analysts and modellers of energy demand behaviors.

Literature Review

Three separate areas in the literature on energy demand behavior can be identified which are relevant to this study. The most directly relevant are the models of demand for specific energy forms by the industrial, commercial, and residential sectors of the U.S. economy. These models are similar in nature to the ones to be used here, and in fact laid the groundwork for this study. The most relevant studies include Baughman and Joskow (1975), Baughman and Zerhoot (1975), Nissen and Knapp (1975) and FEA (1976). The FEA model is the current source of parameters used in the NEME model, as well as the source of the specification of NEME's energy use adjustment mechanism. Hausman (1975) has written an important critique of these models. A second area relevant to this work includes the estimations of Hudson and Jorgenson (1975), Berndt and Wood (1975), and Griffen and Gregory (1976). These studies are concerned with the extent to which energy (aggregated), capital, and labor are substitutable or complementary inputs. Those studies provide insights into both the incorporation of capital and labor issues into the energy demand debate and the estimation procedures for and subsequent

interpretation of our estimated models. Work by Harbridge House, Inc. (1977) and Brainard et al. (1976) at the Brookhaven National Laboratory, as well as work by the Massachusetts Energy Office, which examine some of the technical relationships of energy conservation and energy substitution, are also of interest to this study.

The energy demand models of Baughman and Joskow (1975) and FEA (1976) all utilized a two-step modelling procedure. The first step is to estimate total energy demand as a function of an energy price index, a measure of income, and other relevant variables, such as weather. In the second step, market shares of the specific energy forms, which must sum to the total energy demand, are then estimated as a function of the price of each energy form relative to the energy price index. The rationale behind this procedure is that economic activity levels require certain total energy inputs, but the composition of that energy input can be varied in response to shifting energy prices. Such models were generally estimated by pooling individual state data for the entire U.S. from 1960-1972.

The logic behind the above energy demand models appears convincing until one looks at the restrictions imposed on parameters by the two-step modelling procedure. Hausman (1975), on criticizing these models, has pointed out that such a procedure requires that the cross-price elasticities of derived energy demand for a specific fuel must be equal for all substitutes. He argues that this constraint is unlikely to be accurate, and its imposition will bias the estimates of all parameters if it is in fact incorrect. A relationship between own- and cross-price elasticities is also imposed by this assumption. Nissen and Knapp (1975) observed this problem in their estimation, and chose not to impose the constraint that market shares must add to one. This does not completely solve the problem pointed out by Hausman, however, so a more general model, allowing any combination of own- and cross-price elasticities of demand is desirable. The separation of aggregate energy demand, dependent on the economic activity level, and fuel choice per unit of economic activity, as sought by this two-step modelling procedure is desirable, however.

It will also be desirable to estimate such models using data from New England states only, to determine if behaviors in New England and elsewhere are in fact similar, as assumed by the above models. In addition, extension of the data base to 1975, in order to include post-energy crisis behaviors, and tests of the structural stability of such models over that extended period are also desirable. New England behaviors might differ from overall U.S. behavior: the New England product mix differs somewhat from the U.S. mix, its capital stock may be older, and its fuel mix currently is substantially different from the U.S. mix (FEA, 1975). New England's extreme dependence on petroleum, as compared with the rest of the U.S., may imply a more substantial impact from the 1973 energy crisis than elsewhere in the nation.

The models of Hudson and Jorgenson (1975), Berndt and Wood (1975), and Griffen and Gregory (1976) provide some insight into the design of a less restrictive model though none of those studies disaggregate energy by fuel type. In those studies, derived demands for inputs of capital, labor, and energy per unit of production are derived from general specifications of cost functions for that production. The derived equations determine cost shares for inputs as a function of the natural logarithm of the prices of that input and substitutes for, or complements to, that input. Such a model imposes no prior restrictions on the own- and cross-price elasticities of demand for inputs, though constant returns to scale, and hence linear homogeneity of the cost functions, is imposed on parameter estimation. Extension of such models to our case of several different energy inputs is desirable, though data availability will constrain our model to be only an approximation of their models. In addition, factors such as weather conditions, which are included in the Baughman et al. model (1975), must also be included in some of our derived demand equations, as these have been shown to be important determinants of energy requirements for some (though not all) sectors of the economy.

The principal issue considered by the Griffen and Gregory (1976) study, as well as the earlier studies, is whether or not labor and capital are substitutes for or complements to energy use. Such results are

important, in that policies affecting the prices of labor and capital may be as important as policies affecting energy prices in determining the pattern and extent of energy use in the economy. These considerations suggest that capital and labor prices should be included along with energy prices as arguments in derived energy demand functions. They also suggest that capital and labor inputs may in fact depend upon energy prices.* There is some controversy in this literature over whether capital and energy are substitutes or complements, however, so we will use the results of this study to shed some light on that debate.

The Griffen and Gregory study (1976) also sheds some light on the choice of sample for model estimation, and in particular on the problems associated with pooling cross-sectional (several states) and time-series (several years) data. They point out that cross-sectional price variations have led to long-run and not short-run input adjustments, whereas annual price variations include short-run adjustments in energy use patterns. Two solutions to this problem are possible. Griffen and Gregory include observations from 5-year intervals, rather than annual data, so that estimated parameters are long-run parameters. Madalla (1971) has pointed out that judicious use of regional dummy variables will allow those variables to pick up interstate long-run differences, so incorporation of an adjustment model with such dummy variables, estimated from annual data, will allow estimation of both short- and long-run behavior. Pooling of cross-sectional data and time series data without such dummy variables will result in estimate parameters which are some unknown combination of short-run and long-run effects.

* The effect of energy prices on labor and capital use can be derived from the derived energy demand models under very restrictive assumptions, and utilizing the relationships derived by Allen (1938):

$$e^{ji} = e^{ij} \frac{M^i}{M^j}$$

where M^i is the cost share of input i , and e^{ij} is the elasticity of derived demand for input i in response to change in the price of input j .

The studies of Harbridge House, Inc. (1977) and Brainard et al. (1976) will aid in interpreting our results rather than in the formulation of the model. The most important conclusion from those studies is that technical options which can result in considerable energy conservation exist and appear to be economic, though behavioral or institutional constraints either prevent or slow down the adoption of these options. What this means for our results is that energy price increases may bring about pure energy conservation, since the opportunities for that exist, rather than both conservation and substitution, as required by FEA's (1976) two-step modelling procedure. These studies provide strong evidence that such prior restrictions, as the FEA study imposes on their parameter estimates, are incorrect. Further, little or no cross-price (substitution) effects may in fact occur. Our results will in fact support these points. The institutional and behavioral constraints observed in the Harbridge House report also suggest that derived demand elasticities, especially in the short run, are likely to be low.

All of the above studies have provided guidance in the design of a model to be estimated and for the design of hypothesis tests which can be conducted with such a model. In addition, some of those studies -- particularly the FEA and Baughman et al. studies provide some prior results to which our results may be compared. Those comparisons will be presented with the interpretation of our results, and so the relevant conclusions from those studies will be presented and discussed at that time.

Model Design

The literature discussed in the previous section has suggested a model design which we believe will be an improvement over the models that have been used to estimate the parameters currently in use in the NEME model. Unresolved issues have also been raised in that literature, and our model design attempts to incorporate tests of hypotheses relevant to those issues.

The first lesson learned is that the two-step modelling procedure, in which total energy demand is estimated first and market shares of specific fuels are then estimated, should be abandoned in favor of a less restrictive model. Estimation of energy demand per capita or per unit of product

if desirable, this implies that aggregate energy demands will be determined by the demand for the final products utilizing these energy inputs. The NEME model, which includes direct demand for output functions, can thus use derived demand per unit directly with little alteration. The derived demand functions suggested by the literature would be semi-logarithmic cost share functions including prices of substitutes and complements as arguments. Quantities of energy forms per unit could then be determined from these cost share equations. Unfortunately, regional data for all sectors we wish to consider is inadequate to determine cost shares. Neither adequate production data nor output price data is available. Hence, an approximation to production for each sector has been determined, and physical input-output coefficients (demand for energy forms in BTU's per unit output) rather than cost shares are used as the variables to be explained. These are in fact the variables required by the NEME model, so another justification for their use is that direct estimation of the required parameters is accomplished.

The literature also suggests that the following issues must be addressed in choosing a functional form and independent variables for the model to be estimated:

1. Energy prices may induce pure energy conservation, which can be captured by own-price-derived demand elasticities.
2. Energy prices may induce substitution of energy forms, requiring inclusion of cross-price derived demand elasticities in a model.
3. Institutional and behavioral constraints suggest that economic input adjustments may occur over a reasonably long period of time, and the effect of these constraints may be captured by a lagged adjustment mechanism.
4. Regional dummy variables must be included to insure that estimated short-run parameters in fact capture only short-run behaviors.
5. Energy inputs may be substitutes or complements for capital or labor, so that the prices of capital and labor should also be included in a derived demand model.

6. Certain factors, such as annual variations in weather for the commercial or residential sectors, or variations in income per household for the residential sector, may influence energy demands per unit.
7. The perceived convenience of electricity or technological change may cause shifts in energy use patterns not accounted for by the above effects. These phenomena may be crudely captured by inclusion of a time trend.

A simple model which includes the above considerations would be:

$$\left(\frac{\text{Use of Energy Form } i}{\text{Production in Sector } j} \right)_t = f \left(\frac{\text{Use of Energy Form } i}{\text{Production in Sector } j}_{t-1}, \text{Energy Prices, Rental Price of Capital, Labor Cost, Weather, Income, Time, Regional Dummy Variables} \right)$$

where t represents the time period. Clearly, not all variables belong in models of sectors which differ as much as the manufacturing, commercial, or residential sectors, as the behaviors of each sector can be expected to differ from other sectors. Hence, each of these sector's behaviors will be estimated separately using a model relevant to that sector's behavior.

The problem mentioned earlier, that regional production is unavailable, must be addressed before specific models can be chosen. For the residential sector, the household is the typical behavioral unit, so that energy use per household, rather than energy per some "production" unit, was chosen as the proper dependent variable. For the commercial and manufacturing sectors, most production indices (such as are used by the Federal Reserve Bank of Boston [Behrman, 1977]) are based on employment data. Therefore, we chose to use employment, adjusted by sectoral labor productivity, as our production index for those two sectors. Hence, the production unit is a standard ("efficiency") man-years output in that sector.

The standard models chosen for the residential, commercial, and manufacturing sectors are presented in Tables 1, 2, and 3, respectively. The notation used is also presented in those tables. These standards models were estimated for each important energy input to a sector, except

where empirical results suggested an alternative model specification. A single dummy variable allowing the constant term to differ for states in northern New England (Maine, New Hampshire, and Vermont) and southern New England (Massachusetts, Connecticut, and Rhode Island), rather than the inclusion of a separate dummy variable for each state, was justified by the results obtained when the latter specification was estimated.

Two additional problems had to be dealt with in choosing the appropriate model specification. The first was the inclusion of the price of coal in models where coal is a potential substitute for the energy input being considered. The available data on that price was accurate to only one significant digit, so use of that data series would cause a severe errors-in-measurement problem. In addition, environmental regulations imposed in 1969 required that more expensive coal (low-sulfur) be used to replace previous coal sources. We decided to exclude the coal price in all cases, and presumed that some combination of the included time trend and a dummy variable, which allows the constant in derived demand equations before and after 1969 to differ, would capture the effect of the decline in coal utilization in the region on the use of other energy forms. Where such variables appear to be important, they were included in the standard specification. The estimates of these parameters, in models in which their effects were not important, are also presented.

It was also felt that the effect of variations in interest rates (and hence, capital costs) might affect the time over which adjustments occur rather than the choice of capital and energy inputs which are either substitutes or complements. That is, as the cost of borrowing decreases (increases), firms or individuals are more (less) willing to borrow in order to change their energy using capital stock. This effect can be crudely captured by assuming the lagged adjustment parameter in the standard model, λ , is a function of the cost of borrowing to a sector. Models utilizing that assumption were estimated, and the estimated effects of interest rates on λ will also be presented. Since this is only a crude means of capturing this effect, this specification was never considered to be the standard specification, and the estimates obtained will simply be used as indicative evidence on this phenomenon.

It was also mentioned earlier that some change in the behaviors represented in these models might have occurred in response to the events termed the "1973 energy crisis". Such a shift in behaviors would constitute a structural change in the model, and would suggest that estimating the model using data both before and after 1973 is an incorrect approach. We explored two means of testing for such a structural shift. We estimated separately the models described earlier for data from 1960-1972 and for 1974-75 (where possible) and compared the predictions of those models to those of the model estimated using all years. This latter specification, viewed in this context, imposes the constraint that parameters did not change after 1973. The "cost" of imposing that constraint can then be examined to determine if the data supports the hypothesis that the model must have changed after 1973, or if it did not.

Another way of modelling structural change is to presume that the behavioral responses to price shifts remain unchanged after 1973, but that there is a change in the constant after 1973, due to a shift (translation) of the prior model. This change can be modelled by the inclusion of a dummy variable equal to 1 after 1973 and 0 otherwise. All standard specifications were estimated with this dummy variable included, in order to test for the possibility of this shift in behaviors.

Economic theory relevant to the specification of this model combined with previous empirical results may be used to formulate prior expectations on the signs, and to a lesser extent, the magnitudes of the parameters included in the standard model. The results obtained from estimation of this model can be compared to those prior expectations to assess the reasonableness of estimation results and indicate any problems which remain. The coefficient λ , for example, captures the inability of a sector to adjust its capital stock and behaviors in the short run. Hence, a positive value, approximately equal to 0.8 is expected. Such a magnitude for λ implies long-run adjustment is 5 times greater than short-run adjustment, and after 5 years only 67% of the estimated long-run adjustment will have occurred. Larger values of λ imply longer adjustment periods, and smaller values imply shorter periods.

Economic theory suggests, but does not require, that own price effects, as captured by the inclusion of the price of the input and hence ϵ^i , be negative. That is, as the price of an input rises, its use per unit will diminish. Prior results suggest that short-run estimates will be small, but long-run estimates may approach 1 in elasticity terms. The values of variables used in estimation have been multiplied by appropriate constants, so that estimated values for ϵ^i (and ϵ^{ij}) are reported in elasticity form*, based on 1974 market data. Economic theory also suggests that the parameters associated with the prices of other energy inputs, capital, and labor will be positive if the other inputs are gross substitutes and negative if they are complements. Hence, it is likely that the elasticities associated with other energy inputs and labor will be small positive numbers, whereas the elasticity of demand with respect to the price of capital may be positive or negative - and its sign is of particular interest in this study. These cross-price effects should be smaller than the own-price effects. Again, results are reported in elasticity form.

The weather index is intended to capture the effect of higher energy consumption in colder states or colder years. A strong positive coefficient is expected, and because of the units chosen, the magnitude of the coefficient will be small. The income variable in the residential sector models should be positive for superior fuel types, and possibly negatives for inferior fuel types, such as liquid gases and kerosene. It may be difficult to separate income and time trend effects as well. Time trends parameters could potentially capture several effects, so with the exception of electricity, no prior expectations have been formulated.

* An elasticity ϵ^{ij} is the percentage change in quantity demanded as a result of a 1% change in price, including other factors constant. The model is not a constant elasticity model, so one year's data (1974) must be chosen to convert parameters to elasticities. Two kinds of elasticities are possible: Allen Partial elasticities which hold both price of substitutes and complements and output constant; and market elasticities which hold only the prices of substitutes and complements constant. Allen partial elasticities are reported here; they will be less than 10% smaller than market elasticities for inputs such as energy, which never accounted for more than 10% of total production costs.

Since electricity is considered a more convenient energy form, some shift towards increasing electricity use (a positive time trend coefficient) is likely.

With the above considerations in mind, the standard and alternative specifications for several energy demand models were estimated.

Model Estimation

Models of the derived demand for energy for the residential, commercial, and manufacturing sectors of the New England economy were estimated utilizing the models referred to in the previous section of this report. Energy forms examined in each sector include:

<u>Residential</u>	<u>Commercial</u>	<u>Manufacturing</u>
Electricity	Electricity	Electricity
Distillate	Distillate	Distillate
Natural Gas	Residual	Residual
Liquid Gases	Natural Gas	Natural Gas
Kerosene		Liquid Gases
		Kerosene

Sectoral definitions and energy form definitions are consistent with those used in the NEME model (Abbott, 1976). Several problems in data collection and preparation and in choice of estimation technique need to be addressed, and our approach is presented below.

Data Collection and Preparation

Models were estimated using annual data from each of the New England states as separate observations. Available annual data began in 1960, and inclusion of a lagged endogenous variable plus corrections for serial correlation (to be discussed later) required that model estimation use 1962 as the first sample period. Lack of early data on natural gas use in Maine and Vermont meant that sample periods for natural gas models in those states only began in 1968. The last complete year for the necessary data was 1975 so our estimation period ends in that year. Since price ceilings were imposed in 1973 and the events of that period suggested that quantitative restrictions in supply, rather than demand, determined market outcomes, 1973 was excluded from our sample.

The data series chosen to represent the variables in the models to be estimated as well as sources for that data are presented in an appendix. Data collected included energy use by sector and form, labor use by sector, number of residential households, labor productivity data, prices of energy forms, interest rates, labor costs, deflators, the degree-days weather index, and gross state incomes. The specific variables chosen and transformations of basic data are also presented in that appendix.

Estimation Problems

Since the models to be estimated are all demand equations, they are possibly part of a simultaneous equation system. Therefore, the identification problem must be addressed. That is, we must insure that our coefficient estimates are indeed demand parameters and not some combination of supply and demand parameters. Since New England represents only a small part of total energy demand, and whatever happens in New England is unlikely to affect supply behavior, it is likely that energy prices are set exogenously by a supply equation incorporating none of the variables in New England demand models. Hence, we believe energy prices are pre-determined and not simultaneously determined by quantities demanded in New England. The one possible exception to this is electricity demand, but we presumed that since all input prices to the electricity sector are pre-determined, so is its output price. These assumptions are consistent with the national energy and supply demand models of the FEA and for the most part, correct signs for price elasticities were obtained. Hence, we have concluded that simultaneity bias is not likely to be a serious problem with these estimates.

All models were estimated utilizing a Cochran-Orcutt iterative least squares regression procedure. This procedure corrects for temporal serial correlation, assuming the serial correlation process is the same for all states. Inclusion of a lagged endogenous variable (energy use per unit in the previous year) in a model requires this correction, as otherwise estimated coefficients could be biased and inconsistent. The best test for this problem is to correct for serial correlation and examine the significance of estimated serial correlation coefficients, so that procedure was

followed. Since cross-sectional serial correlation will not bias parameter estimates, no correction for the possibility of that problem was applied. Estimation of a variance-components model of the error process in this model could lead to more efficient parameter estimates, but the expense and time required to make such corrections were prohibitive.

In addition, no prior constraints were placed on parameter estimates. The constraints required by linear homogeneity, as imposed by Griffen and Gregory or Berndt and Wood were considered, but are non-linear for our model structure and so were not imposed. The cost of not doing so is simply to decrease efficiency, and the cost of imposing an incorrect constraint is to bias coefficient estimates. Since it was clear that efficiency in estimation was an unobtainable goal, we have opted throughout for consistent estimation procedures. Hence, no prior constraints are imposed. There is also no reason to presume, a priori, that the actual cost functions are truly nearly homogeneous.

A heteroskedasticity correction was also applied to all data. That is, since sample population sizes varied, the variances of error terms are likely to vary as well. In the household sector all data were multiplied by square root of the number of households, and in the commercial and industrial sectors all data were multiplied by the square root of the employment (production index) for that sector in order to make the variances of errors equal for all observations.

With these corrections applied and using the indicated models, consistent estimates of all parameters should be obtained. Where possible, corrections leading to more efficient estimators have been employed.

Estimation Results

Estimates of the standard specifications of our models are presented in Tables 4-8 for the residential sector, Tables 9-12 for the commercial sector, and Tables 13-18 for the manufacturing sector. These represent the best estimates of the demand for an energy form by a sector, in terms of first, the reasonableness of coefficient estimates (as judged by correctness of the sign of the parameter and then order of magnitude), and then in terms of explanatory power of the regressions.

The resulting coefficient estimates are well-behaved and largely consistent with prior expectation, with one possible area of exception; and explain well the observed dependent variables. The lagged adjustment coefficients fall within a range of 0.961 to 0.465 and were in general quite close to the prior expectation of 0.8, as well as being always positive. These suggest relatively slow adjustments to price changes, especially for the major fuels. Own-price demand elasticities were negative, with two exceptions. The equation explaining distillate use by the commercial sector appears to have captured the effect of petroleum price on use through the residual price cross-elasticity, which is not surprising, since distillate and residual prices are highly colinear. In the equation explaining use of liquid gases by the manufacturing sector, a negative but significant (hence, most likely zero) coefficient was found.

The one set of parameters for which incorrect signs were occasionally obtained were the cross-price demand elasticities. These incorrectly signed estimates were often not significantly different from zero. In those few instances where that is not the case, an explanation of the observed estimates is not yet apparent.

Instead of presenting a complete discussion of each equation in this section, we will discuss interpretation of results coefficient-by-coefficient (rather than equation-by-equation) and will address specific hypotheses in the next section of this report.

In addition to the standard specification models, several alternative specifications were also estimated for each case. These either examined the possibility of including an exogenous time trend or dummy variables for coal price effects, or considered the hypothesis that a change in the cost of borrowing altered the lag structure of the model, and hence the adjustment process. The crucial parameter estimates are presented in Table 19, and where these results are important to hypothesis tests, they will be discussed in the next section of this report. The complete model estimations, including these variables, have been provided with the Appendix.

As noted earlier, sample periods of model estimations were split around 1973, and models were estimated including a dummy variable which allowed a translation of the estimated equation after 1973. These model estimations are used to test for the possibility of structural changes in energy demand behavior. Due to the events of the 1973 "energy crisis", only the statistics used to conduct the relevant hypothesis tests are presented and these are in Table 20. Again, complete, model estimations are available in the Appendix.

Interpretation of Results

Several hypotheses and specific parameter estimates are of interest to this study. The main purpose of this study was to produce regional estimates of price parameters in a model of energy demand by the residential, commercial, and industrial economic sectors. The proper specification of a model to be used in estimating those parameters was an issue, as was the relevance of parameters estimated from national rather than regional (New England) data. In addition, the possibility of a change in underlying behaviors due to events of the 1973 "energy crisis" was also examined. Other issues were also raised earlier in this report, including the effect of labor and capital prices, and income on energy use patterns. These issues will be considered separately below.

Price Elasticity Issues

As mentioned earlier, the estimates of price elasticities obtained here were generally consistent with prior expectations. Negative own price effects and positive cross-price effects were obtained in most instances. On the other hand, most of our price elasticities were relatively small (i.e., much less than one), though they were also significantly greater than zero. In the residential sector, own-price elasticities ranged from -0.1 to -0.4, except for kerosene, where a very large elasticity of -2.4 was found. In the commercial sector, very low or, in effect, zero own-price elasticities were found for the use of distillate and residual petroleum. Elasticities for electricity and natural gas use were somewhat larger (around -0.4) but still exhibited inelastic demand behaviors. In the manufacturing sector, own-price elasticity for distillate demand was quite large, and elasticities of about -0.2 were found for the other fuels

used. It should be noted that this relatively inelastic behavior corresponds to adjustments to price changes which occur over a one-year period. They generally indicate that demand is somewhat price-responsive in that time span. Examination of cross-price elasticities and the lagged adjustment mechanism must be examined to determine just what behaviors are behind these inelasticities.

The relatively large lagged adjustment coefficients (λ 's) which range from 0.465 to 0.961, indicate that the adjustments of energy use patterns in response to price changes occur over a relatively long time, so that long-run own-price elasticities will be substantially larger than the one-year elasticities discussed above. For the model estimated here, long-run elasticities (both own-price and cross-price) may be derived from the estimated one-year elasticities and the lagged adjustment coefficient. That model structure may also be used to estimate the cumulative effects of a price change over any specified number of years. That is:

$$\epsilon_{n\text{-years}}^{ij} = \epsilon_{\text{one year}}^{ij} \left(1 + \sum_{k=1}^{n-1} \lambda^k \right)$$

where ϵ_n^{ij} is an elasticity measuring the price-responsiveness of demand over n years, and $\epsilon_{\text{one year}}^{ij}$ is an estimated one-year elasticity. With $0 < \lambda < 1$, the long-run elasticity (theoretically, for $n \rightarrow \infty$) is given by

$$\epsilon_{\text{long-run}}^{ij} = \frac{1}{1-\lambda} \epsilon_{\text{one year}}^{ij}$$

These equations have been used to convert the estimated one-year elasticities to long-run elasticities, using the estimated lagged adjustment coefficients. The results of these calculations are reported in Table 21, along with similar estimates of these elasticities obtained in other studies. These results indicate that for most fuels, long-run own-price elasticities are often close to or greater than 1, which corresponds to relatively elastic long-run price responsiveness. For the residential sector, only distillate demand is relatively inelastic in the long run, with an estimated long-run elasticity of approximately -0.6. In the commercial sector, only residual demand is relatively inelastic, and if the distillate price is picking up

the effect of own-price changes, as multicollinearity and the observed perverse behavior would suggest, then that demand is also elastic. In the manufacturing sector, inelastic behaviors were found only for natural gas (where quantitative restrictions in the market may have biased our estimates) and for electricity. The interpretation of these results is that price changes will alter energy use in each of these sectors, but that adjustments will take a relatively long time (greater than one or two years) to occur. If price policies are then to be used to influence energy demand, policy makers and those who evaluate policies must wait patiently for those long-run effects to take place.

Another issue which must be addressed is whether these price responses are due to energy conservation or energy substitution. This is of interest to policy makers who must decide whether the policies to be imposed will bring about an overall reduction in energy use or will redirect energy use to possibly more desirable forms. Estimates of cross-price elasticities will provide evidence on this issue. Very small or zero cross-elasticities suggest own-price elasticities reflect price-induced energy conservation, and relatively large own-price elasticities suggest energy substitution.

Cross-price elasticities either significantly greater than zero, or of a reasonable magnitude but with a relatively large estimation error, were found in a limited number of cases. In the residential sector, only natural gas use appeared to adjust to changes in prices of other energy forms to any substantial degree. The only other cross-price elasticity greater than 0.1 which was found in the residential sector was for electricity use in response to the price of liquid gases. Since liquid gas use is very small relative to electricity use, this result cannot suggest much energy substitution. Hence, in the residential sector, own-price effects appear to induce energy conservation for the most part. In the commercial sector, similar results were obtained. Reasonable estimates of cross-elasticities were found for natural gas and electricity demand only. On the other hand, a very large own-price elasticity for electricity

use by the commercial sector was found. Again, it appears that energy conservation dominates energy substitution. In the manufacturing sector, the only energy substitution observed was between residual and distillate petroleum. Given the similarity between these two fuel forms, substantial substitution is not surprising. It is interesting that substitution with other less similar fuel forms was not observed.

It is important at this point to explain this energy conservation result, which is inconsistent with a view that total energy is what really matters in energy demand decisions, and energy forms are substituted to meet the total energy need in response to price shifts. It was pointed out earlier that several studies (Harbridge House and Brainard et al.) have observed that substantial and economic energy conservation measures are available to all sectors of the economy, though institutional or behavior constraints appear to slow down the adoption of those measures. Apparently, price changes can affect the rate of adoption of these measures, and conservation options dominate any substitution which might occur. In light of these studies, our findings of very low or zero cross-elasticities are not unreasonable.

These results and subsequent interpretations are in some ways similar to but in other ways different from those of other studies which estimate similar models (FEA; Baughman and Joskow; and Baughman and Zerhoot). Those studies utilized the two-step modelling procedure which, as noted earlier, imposes restrictions on the own- and cross-price elasticities. In effect, that modelling procedure guarantees the existence of substantial cross-price effects and, therefore, energy substitution. The estimated parameters of these models have been converted by those authors to market elasticities, which should be somewhat, but not substantially, greater than the Allen partial elasticities presented here. A comparison of those elasticities and our estimates is presented in Table 21, and will be used to assess the validity of the two-step modelling approach and the relevance of their estimates to New England energy demand behaviors.

The comparison of own-price elasticity estimates in Table 21 indicates strong agreement between our estimates of New England parameters and both the FEA and Baughman et al. estimates. This suggests that underlying national and regional behaviors are very similar. Hence, it would be reasonable to use those estimates, based on U.S. data, as approximations to regional parameters. Comparisons of cross-price elasticities do not indicate the same degree of agreement. Our estimated cross-price elasticities are significantly smaller than those found in the other studies. Given the agreement between estimated own-price elasticities, this result must be explained by biases introduced by the two-step modelling procedure and resulting restrictions on price elasticities, and not by the use of a New England rather than a U.S. sample. This result is strong evidence that the restrictions on parameters resulting from the two-step energy models are incorrect, and a less restrictive model must be used to estimate such parameters. These results justify our selection of a direct equation explaining energy use by energy form per unit of production, rather than using total energy, and then market shares as dependent variables.

Based on the above results, we have determined a set of own- and cross-price elasticities which we believe represent the best available estimates of such parameters for the NEME model. Those elasticities are presented in Table 22. Where incorrectly signed, or insignificant and unreasonable estimates were obtained, we have substituted an estimate of zero - the most likely value based on both econometric evidence and theory. The above evidence on the relevance of U.S. data, however, suggests that improved estimates might be obtained by re-estimating our model, utilizing FEA's national data base. The elasticities in Table 22 have been converted to 5-year rather than 1-year elasticities, using the lagged adjustment structure indicated earlier.

Structural Shift

Another issue of interest to those concerned with the effect of price policies on energy demand is whether the dramatic events in energy markets during 1973 and early 1974 have altered substantially the underlying behaviors of energy users. The question to be addressed here is

whether estimated parameters for our demand models are stable after 1973, or whether they are extremely sensitive to choice of the estimation period. That is, are the price effects observed prior to 1973 sufficient to explain any changes in energy use patterns after the dramatic price increases of 1973, or must additional behavioral mechanisms be used to explain such changes.

Two tests have been conducted to determine whether such structural shifts did in fact occur. One such procedure was to re-estimate a re-specified model which allowed two constant terms - one before 1973, and one after 1973. That model presumes that the basic price behaviors remained unchanged, but that some phenomena not captured by the model accounted for changes in energy demand patterns after 1973. The estimated coefficient for the dummy variable TSHIFT corresponds to the increase in the constant term after 1973. A negative coefficient implies a decrease in the use of that energy form and a zero coefficient implies no change in the constant term. Hence, a significantly non-zero coefficient is evidence that this type of structural change has occurred, and an insignificant coefficient indicates no such changes. The t-statistics for these coefficients, equal to the estimated coefficient divided by its standard error, will be greater than 1.7 or less than 1.7* if the coefficients estimated are significantly different from zero. The t-statistics for the coefficient on TSHIFT have been reported in Table 20.

Five cases of significant coefficient estimates have been found. In the residential sector, a decline in distillate use is indicated, which corresponds closely with the notion that problems in the petroleum market caused some reduction in use which are not explained by prices. Liquid gas use in the residential sector also appears to have declined over this period. No significant coefficients were found for the commercial sector. In the manufacturing sector, it appears that energy users switched to the less expensive residual fuel, even though its price more than doubled, whereas the price of distillate increased only about 75%. What seems to

* Based on the number of degrees of freedom for our model estimations.

have happened is that the overall increases in petroleum prices, and not relative price shifts, drove users to the less expensive fuel. It is also interesting to note that natural gas use increased, which may have been due to the fact that prices were held artificially low by regulation, making natural gas more attractive than the alternatives. In no other energy use category was a significant coefficient found. In addition, those energy use shifts which correspond to these coefficients are quite small relative to the amount of fuel per unit of production.

The other test for structural change was a general test for all coefficients of the model. The hypothesis to be tested was the assumption that no parameters changed after 1973. This test is accomplished by re-estimating the model separately before and after 1973. A comparison of the accuracy of prediction with the original model, which assumes no coefficient changes after 1973, with the accuracy of prediction using separate models before and after 1973, is then made. An F-statistic calculated from a ratio of the increase in prediction errors, resulting from imposing the constraint that no coefficients change, to the prediction errors in the separate models, allows one to determine if a statistically significant loss in predictive power results from the constraint. For our sample and models, an F-statistic greater than 2.0 indicates that such a significant loss in prediction occurred, and hence it is unlikely that model coefficients remained stable after the 1973 energy crisis. An F-statistic less than 2 corresponds to the hypothesis that coefficients in fact did not change.

The F-statistics relevant to this test are also reported in Table 20. In only one case did we find an F-statistic greater than 2. Only residential use of distillate appears to require a new set of parameters to explain behaviors after the energy crisis, and since the coefficient is only slightly greater than 2, that evidence is very weak.* All other F-statistics indicate that our models remain relatively stable after the

1973 energy crisis, so that using data both before and after that period to estimate model parameters is justified.

The behavioral conclusion indicated by these results is that not only petroleum use appears to have been significantly affected by the events of the 1973 energy crisis, primarily in the residential sector and to a lesser extent in the manufacturing sector. In addition, the effects were relatively small. Hence, predictions of price policy effects using results from our models appears to be justified by the empirical evidence. The structural shift for petroleum use does indicate, however, that policies which increase user awareness of energy problems and energy conservation possibilities may have small effects, as happened in that case.

Capital, Labor and Energy Substitution

Another question of interest to this study is whether capital, labor and energy are gross substitutes or complements, and to what extent such substitution might be induced by changes in interest rates or wages. If this substitution is important, energy policy makers must be aware of policies such as national monetary policy which may affect those prices and subsequently affect energy demand as well. Labor and capital prices have been included in our models of the commercial and manufacturing sectors so that this issue could be examined, and coefficient estimates are reported in Tables 4-18.

The evidence obtained here on an effect of these prices on energy use through a substitution or complementary effect is very weak. In only one case were coefficients significantly different from zero (and hence, a likely effect) found. On the other hand, Hogan (1977) has argued that gross complementarity as indicated by Allen partial demand elasticities does not correspond to a true fixed coefficients model. Rather, if inputs are perfect complements according to Leontief production functions, prices will have no effect on input-output coefficients. Our results agree with his interpretation, and indicate that energy use coefficients are largely unaffected by changes in labor and capital costs. The one exception to

* We have already seen that the likely change is a shift in the constant term.

that finding is noteworthy, however. In the commercial sector, electricity use depends significantly on both labor and capital price, and both are found to be substitutes for electricity inputs. Since no significant exogenous time trend was found, these results indicate that the apparently exogenous increase (trend) in electricity use by that sector can be explained quite well by increasing labor costs and interest rates driving employers towards more energy-intensive production techniques.

Cost-of-Borrowing Effects

The possible effect of changes in interest rates on energy use through capital-energy substitution is not the only way in which interest rates might affect energy use patterns. The models estimated also include a lagged adjustment mechanism. One reason why such a mechanism, which allows relatively slow changes in demand patterns in response to price changes, is included is that changes in energy use patterns require substantial alteration of a user's capital stock (such as a homeowner's or office building's furnace, or the machinery used in manufacturing). Investment in capital stock often requires borrowing, and in any case the cost of borrowing affects the opportunity cost of an investment.* Hence, changes in interest rates may alter investment plans and, therefore, the rate at which energy conservation or substitution is implemented. The effect of interest rate changes may then be to alter the lag structure of our model rather than directly affecting an energy use coefficient.

In order to examine this effect, all models were re-estimated including an independent variable equation to the product of the energy use coefficient in the previous period and the cost of borrowing. The coefficient estimated for this variable (λ^r) is in effect the rate of change of the lagged adjustment coefficient in response to changes in the cost of borrowing. A positive coefficient indicates that increases in the cost of borrowing slow down the adjustment process, and so slow down the adoption of energy saving measures.

Our estimates of λ^r are presented in Table 19. They indicate

* The opportunity cost is the value of foregone alternatives.

that interest rates are more likely to have an effect on energy demand behavior through this mechanism than through capital-energy substitution or complementarity. Five significantly positive coefficients were found, which suggests strongly that this effect may exist. Only three incorrectly signed coefficients were found as well, two of which were not significantly different from zero. The significantly positive coefficients were found for residential use of natural gas and liquid gases, commercial use of natural gas and manufacturing use of electricity, natural gas and liquid gases. Petroleum use adjustments, on the other hand, appear to be relatively insensitive to changes in the cost of borrowing.

It should be pointed out that this means of measuring the effect of borrowing on energy use adjustments is relatively crude and inaccurate. That is why this mechanism was not included in estimates of the standard model specification. Nevertheless, this evidence does suggest that interest rates are more likely to effect the speed of energy use adjustment than choice of inputs.

Weather

A weather index was also included in the residential and commercial sector models to capture the effect of colder years and colder climates on heating requirements. Significantly positive coefficients were found for residential use of distillate, natural gas and liquid gases. This is consistent with the notion that variations in the weather will induce variations in energy demand in the residential sector. This effect has little policy significance but does improve model estimation. No significant coefficients were found for the commercial sector. Evidently, either heating requirements for commercial buildings are not as sensitive to weather variations as in the residential sector, or variations in energy use resulting from productive activity dominates variations in heating requirements. It should also be noted that the weather index is a yearly aggregate, and years in which these yearly aggregates are similar may correspond to different heating requirements, if the variations in temperature making up that aggregate are different. Hence, the estimated coefficient should only be thought of as an inaccurate estimate of the effect of weather on energy demand.

Income

The effects of variations in income on energy demand were also included in our models of the residential sector. A significantly positive coefficient was found for electricity use only. Evidently, increases in household income has encouraged people to increase their use of this convenient energy form and to move towards more energy-intensive lifestyles. Income appears to have little effect on the use of other energy forms by the residential sector.

Coal Price Effects

As noted earlier, data on coal prices and coal use in New England is poor. This is not surprising, since very little coal is now used in New England by the residential, commercial, or manufacturing sectors. We felt that the coal effects could be reasonably ignored in the residential and commercial sectors. On the other hand, relatively substantial amounts of coal were used by New England's manufacturing sector in the early 1960's, and some means of including the potential effects of the decline in coal use by that sector needed to be considered. Models which included an exogenous time trend for all fuels were estimated in order to capture possible increases in demand for other fuels in response to the decline in coal use. Results in Table 19 suggest that only electricity use demonstrated a significant exogenous time trend, and this can be explained by factors other than coal use. In addition, a dummy variable intended to capture the effect of strict environmental regulations adopted in 1969 and the subsequent acceleration of the decline of coal use in the region was also included in the model. A significant coefficient for that dummy variable was found only for manufacturing use of electricity. This, and the time trend result, are weak evidence that manufacturers switched from coal-using production techniques to modern, electricity-using techniques. There is no evidence of a switch from coal to residual petroleum, as was initially expected.

Conclusions

Conclusions in three distinct areas may be drawn from the above findings. First, evidence on the proper specification of derived demand models used to estimate energy use patterns has been found. This evidence and other results then suggest alterations in the structure of the NEME model as well as new parameters to be used in that model. Finally, some direct policy conclusions may be drawn from these results.

The estimates obtained here and arguments in the literature (i.e., Hausman) suggest strongly that the two-step modelling procedure utilized by FEA and Baughman *et al.* imposes incorrect restrictions on demand elasticities and causes biased estimates of cross-price elasticities. A less restrictive model is mandatory if reasonable parameter estimates are to be obtained. Such a model, which is based on literature addressing estimation of aggregate demand (i.e., Griffen and Gregory) is both suggested and estimated using New England data. That model explains input-output coefficients of energy use as functions of energy prices and other variables. It preserves the separation of the effects of energy prices on aggregate demand for product and choice of technology, while imposing no prior restrictions on derived demand elasticities.

On the other hand, use of national data to estimate energy use parameters, or the use of national parameters in a regional model, appear to be justified. This conclusion is a result of the observation that own-price demand elasticities found here using regional data and found elsewhere using national data are quite similar. Differences in cross-price elasticities are probably due to restrictions imposed on models used to estimate national parameters, and not on the different data bases used.

Also, these models appear to be relatively stable, even when dramatic price changes occur, as happened in 1973. Hence, estimation of parameters using data both before and after such events such as the 1973 energy crisis is justified. More importantly, parameters relevant to the earlier time period will also be appropriate for predictions of future energy use.

These findings suggest that the NEME model should incorporate the direct derived demand model presented here in place of the two-step modelling procedure presently used. In addition, regional parameters are now available for use in that model. Given the problems of the two-step modelling procedure, it is likely that these regionally estimated parameters are better estimates of cross-price energy demand elasticities, though they are not very different from estimates of national own-price energy demand elasticities. The NEME model will be reprogrammed to include this improved model structure in a subsequent phase of this project. Re-estimation of the national parameters, utilizing our model structure, would provide an interesting test of some of the above conclusions and might also lead to more accurate estimates of the cross-price energy demand elasticities.

More work on the treatment of capital and energy prices is also desirable, as evidence on the proper specification of mechanisms affecting energy demand which depend on these prices is weak. Such work is important if energy policy makers are to accurately assess the impact of policies affecting capital and labor costs on energy use patterns. The present evidence suggests that inclusion of labor-energy substitution, particularly for commercial use of electricity, and the effect of the cost of borrowing on the rate of energy use adjustment as options in the NEME model, is desirable. Such options will also be included in the subsequent reprogramming of the NEME model.

The first policy conclusion which should be drawn from our results is that price policies are likely to be effective means of altering energy use patterns. Significant own-price energy demand elasticities were found in many cases and reasonable estimates were found in virtually all cases. On the other hand, these price effects appear to correspond to induced energy conservation rather than energy substitution. Our estimates of zero or near zero cross-price energy demand elasticities support that conclusion. It should also be pointed out that this study does not examine the possibility of inducing this conservation by other means, such as public education or subsidies to industrial or resident users. The observed effect of

prices on energy conservation does suggest weakly, however, that subsidies which affect energy costs to users and encourage conservation are likely to be effective.

These optimistic conclusions must be tempered, however, by the observation that energy use adjustments in response to price changes occur over a long period of time. At the end of one year, in most cases, only a small part of the total effect of a price change has been felt. Policy makers must be content with waiting patiently for long-run effects to occur and cannot judge the effectiveness of a policy after only one year. Adjustments in energy use patterns are likely to take ten years or longer to occur.

We also found that capital and labor prices in some cases will affect energy use so that economic policies not strictly addressing energy problems may be important. Explanation of exogenous increases in electricity use in the commercial sector as a result of higher labor costs in the region is strongly supported by our evidence. It is also likely that changes in the opportunity cost of capital, and so the cost of borrowing to those considering energy-related investments, may affect the rate of adoption of energy conservation measures if not the choice of production techniques.

A complete assessment of the importance of our findings requires simulation of not only derived demand per unit of production but also the macroeconomic effects of proposed energy policies, utilizing the estimated parameters and an economic model such as the NEME model. Hence, reprogramming of the NEME model and incorporation of these new parameter estimates, along with simulation of energy programs such as President Carter's proposed policies, will illustrate more fully the significance of these findings for the effectiveness of price-based energy policies.

Table 1

Standard Specification

Residential Sector

$$\begin{aligned}
 \text{Energy Use Coefficient } \frac{im}{t} = & \text{Constant} \\
 & + D^i \quad . \quad (\text{Northern States Dummy } \frac{m}{t}) \\
 & + \lambda^i \quad . \quad (\text{Energy Use Coefficient } \frac{im}{t-1}) \\
 & + \epsilon^i \quad . \quad \text{LOG (Energy Price } \frac{im}{t}) \\
 & + \sum_{j=1}^k \xi^k \epsilon^{ij} \quad . \quad \text{LOG (Energy Price } \frac{j^m}{t}) \\
 & + w^i \quad . \quad (\text{Weather Index } \frac{m}{t}) \\
 & + I^i \quad . \quad (\text{Income } \frac{m}{t}) \\
 & + T^i \quad . \quad (\text{Time Trend } t) \\
 & + \epsilon_t^{im}
 \end{aligned}$$

where:

$$\begin{aligned}
 \text{Energy Use Coefficient } \frac{im}{t} &= \frac{(\text{Use of Energy Form } i)}{(\text{\#Households})} t \\
 \text{Northern States Dummy } \frac{m}{t} &= \begin{matrix} 0 & \text{for Mass., Conn., R.I.} \\ 1 & \text{for Maine, N.H., Vermont} \end{matrix} \\
 \text{Energy Prices } \frac{j^m}{t} &= \text{Real Price of Energy Form } j
 \end{aligned}$$

(ϵ^i are adjusted to be Allen Own Price Partial Elasticities, and ϵ^{ij} are Allen Cross Price Partial Elasticities. Relevant energy substitutes are included in the standard specification.)

$$\text{Weather Index } \frac{m}{t} = \text{Heating Degree Days } \frac{m}{t}$$

$$\text{Income } \frac{m}{t} = \text{Per Capita Gross State Product } \frac{m}{t}$$

$$\text{Time Trend} = (\text{Year } t - 1960)$$

$$\epsilon_t^{im} = \text{Random Disturbance Term}$$

$i, j,$ = Energy Form Indicators (i is energy form being modelled)

m - State Index for each of the New England States

NOTE: All Logs are Natural Logarithms.

Table 2

Standard Specification

Commercial Sector

$$\begin{aligned} \text{Energy Use Coefficient } \frac{i^m}{t} = & \text{Constant} \\ & + D^i \cdot (\text{Northern States Dummy } \frac{m}{t}) \\ & + \lambda^i \cdot (\text{Energy Use Coefficient } \frac{i^m}{t-1}) \\ & + \epsilon^i \cdot \text{LOG (Energy Price } \frac{i^m}{t}) \\ & + \sum_{j=1}^k \epsilon^{ij} \cdot \text{LOG (Energy Price } \frac{j^m}{t}) \\ & + \epsilon^{iw} \cdot \text{LOG (Wage } \frac{m}{t}) \\ & + \epsilon^{ir} \cdot \text{LOG (Interest Rate } \frac{m}{t}) \\ & + W^i \cdot (\text{Weather Index } \frac{m}{t}) \\ & + T^i \cdot (\text{Time Trend } \frac{i}{t}) \\ & + \epsilon^{\frac{i^m}{t}} \cdot \end{aligned}$$

where:

$$\text{Energy Use Coefficient } \frac{i^m}{t} = \frac{(\text{Use of Energy form } i)}{(\text{Efficiency Man Years})_t}$$

$$\text{Northern States Dummy } \frac{m}{t} = \begin{cases} 0 & \text{for Mass., Conn., R.I.} \\ 1 & \text{for Maine, N.H., Vermont} \end{cases}$$

$$\begin{aligned} \text{Energy Price } \frac{j^m}{t} &= \text{Real Price of Energy Form } j \\ (\epsilon^i &\text{ are adjusted to be Allen Own Price Partial Elasticities,} \\ \text{and } \epsilon^{ij} &\text{ are Allen Cross Price Partial Elasticities. Relevant} \\ &\text{energy substitutes are included in the standard specification.)} \end{aligned}$$

$$\text{Wage } \frac{m}{t} = \text{Real Average Wage in the commercial sector (per "efficiency"manhour)}$$

$$\begin{aligned} \text{Interest Rate } \frac{m}{t} &= \text{Real Opportunity cost of capital in the commercial} \\ &\text{sector. } (\epsilon^{iw} \text{ and } \epsilon^{ir} \text{ are also adjusted to be} \\ &\text{Allen Cross Price Partial elasticities.)} \end{aligned}$$

$$\text{Weather Index } \frac{m}{t} = \text{Heating Degree Days}$$

$$\text{Time Trend } \frac{i}{t} = (\text{Year}_t - 1960)$$

$$\epsilon^{\frac{i^m}{t}} = \text{Random disturbance term}$$

$$i, j, = \text{Energy form indicators (i is energy form being modelled)}$$

$$m = \text{State index for each of the New England States}$$

NOTE: All Logs are Natural Logarithms.

Table 3

Standard Specification

Manufacturing Sector

Energy Use Coefficient $\frac{im}{t}$ = Constant

$$\begin{aligned}
 &+ D^i \quad \cdot \quad (\text{Northern States Dummy } \frac{m}{t}) \\
 &+ \lambda^i \quad \cdot \quad (\text{Energy Use Coefficient } \frac{im}{t-1}) \\
 &+ \epsilon^i \quad \cdot \quad \text{LOG (Energy Price } \frac{im}{t}) \\
 &+ \sum_{j=1}^k \epsilon^{ij} \quad \cdot \quad \text{LOG (Energy Price } \frac{jm}{t}) \\
 &+ \frac{ic}{D} \quad \cdot \quad (\text{Coal Dummy } \frac{t}{t}) \\
 &+ \frac{iw}{t} \quad \cdot \quad \text{LOG (Wage } \frac{m}{t}) \\
 &+ \frac{ir}{\epsilon} \quad \cdot \quad \text{LOG (Interest Rate } \frac{m}{t}) \\
 &+ T^i \quad \cdot \quad (\text{Time Trend } \frac{t}{t}) \\
 &+ \epsilon^{\frac{im}{t}}
 \end{aligned}$$

where:

$$\text{Energy Use Coefficient } \frac{im}{t} = \frac{(\text{Use of Energy Form } \frac{i}{t})}{(\text{Efficiency Man-Years})_t}$$

$$\text{Northern States Dummy } \frac{m}{t} = \begin{cases} 0 & \text{for Mass., Conn. R.I.} \\ 1 & \text{for Maine, N.H., Vermont} \end{cases}$$

$$\text{Energy Price } \frac{jm}{t} = \text{Real Price of Energy Form } j \text{ (}\epsilon^i \text{ are adjusted to be Allen Own Price Partial Elasticities and } \epsilon^{ij} \text{ are Allen Cross Price Partial Elasticities. Relevant energy substitutes are included in the standard specification.)}$$

$$\text{Wage } \frac{m}{t} = \text{Real Average wage in the Manufacturing Sector (per efficiency manhour).}$$

$$\text{Interest Rate } \frac{m}{t} = \text{Real Opportunity cost of capital in the Manufacturing Sector}$$

$$(\epsilon^{iw} \text{ and } \epsilon^{ir} \text{ are also adjusted to be Allen Cross Price Partial Elasticities})$$

$$\text{Coal Dummy } \frac{t}{t} = \begin{cases} 0 & \text{for } t = 1960-1969 \\ 1 & \text{for } t = 1970-1975 \end{cases}$$

$$\text{Time Trend } \frac{t}{t} = \text{Year}_t - 1960$$

$$\epsilon^{\frac{im}{t}} = \text{Random disturbance term}$$

$$i, j, = \text{energy form indicators (i is energy form being modelled)}$$

$$m = \text{state index for each of the New England States}$$

NOTE: All Logs are Natural Logarithms.

Table 4

Estimated Model - Standard Specification

Residential Sector

Electricity Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	10,222	2.504	4.083
Northern States Dummy	D	1.687	0.572	2.949
Energy Use Coefficient	Λ	0.845	0.043	19.472
Electricity Price	ϵ^i	-0.240	0.034	-7.092
Distillate Price	ϵ^{i1}	-0.0613	0.0318	-1.929
Natural Gas Price	ϵ^{i2}	0.0091	0.0257	0.353
Liquid Gases Price	ϵ^{i3}	0.0622	0.0157	3.973
Weather Index	W	0.000050	0.000130	0.381
Income	I	0.206	0.071	2.917
Time Trend	T	0.0934	0.0665	1.404
Serial Correlation Coefficient	ρ	0.758	0.074	10.274
Number of Observations	= 78	Sample period - 1962-74, 1974-75		
Sum of squared residuals $\sum (\epsilon_t^{im})^2$		= 2,860,230		
Standard error of the regression σ		= 205		
Coefficient of determination R^2		= 0.892	.999	
Durbin-Watson statistic		= 1.988		
Mean on all*		= 12,386		

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard error}}$

*

Table 5

Estimated Model - Standard Specification

Residential Sector

Distillate Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-0.160	21.448	-0.007
Northern States Dummy	D	-3.816	4.369	-0.873
Energy Use Coefficient t-1	λ	0.769	0.039	19.497
Distillate Price	ϵ^i	-0.119	0.067	-1.778
Electricity Price	ϵ^{i1}	-0.0014	0.044	-0.031
Natural Gas Price	ϵ^{i2}	0.0194	0.0347	0.561
Liquid Gases Price	ϵ^{i3}	-0.0425	0.0598	-0.761
Weather Index	W	0.00425	0.00239	1.777
Income	I	0.0823	0.381	0.216
Serial Correlation Coefficient	ρ	-0.463	0.100	-4.608
Number of Observations =	78	Sample period = 1962-72,74,75		
Sum of Squared Residuals $\sum (\epsilon_i)^2$ =		955,770,000		
Standard Error of the Regression $\sigma = \frac{790}{t}$		3721		
Coefficient of Determination R^2 =		0.989		
Durbin-Watson Statistic =	1.958	2.18		
Mean of Dependent Variable =	72490			

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

*
Table 6
Estimated Model - Standard Specification
Residential Sector
Natural Gas Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-8.219	6.004	-1.369
Northern States Dummy	D	-4.473	1.929	-2.319
Energy Use Coefficient t-1	λ	0.945	0.022	42.68
Natural Gas Price	ϵ^i	-0.078	0.047	-1.658
Electricity Price	ϵ^{i1}	0.077	0.033	2.361
Distillate Price	ϵ^{i2}	-0.049	0.055	-0.902
Liquid Gases Price	ϵ^{i3}	0.045	0.045	1.003
Weather Index	W	0.00139	0.00084	1.659
Income	I	0.0933	0.1112	-0.839
Serial Correlation Coefficient	ρ	-0.381	0.115	-3.305
Number of Observations = 64	Sample Period = 1962-72, 74, 75 Except Maine and Vermont			
Sum of Squared Residuals $\sum(\epsilon_t^{im})^2$ =	53,802,600			
Standard Error of the Regression σ =	989			
Coefficient of Determination R^2 =	0.998			
Durbin-Watson Statistic =	1.8766			
Mean of Dependent Variable =	23686			

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 7 *

Estimated Model - Standard Specification

Residential Sector

Liquid Gases Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	1.831	2.912	0.629
Northern States Dummy	D	0.271	0.754	-0.359
Energy Use Coefficient t-1	λ	0.908	0.068	13.303
Liquid Gases Price	ϵ^i	-0.308	0.179	-1.723
Electricity Price	ϵ^{i1}	-0.347	0.204	-1.699
Distillate Price	ϵ^{i2}	0.874	0.278	3.139
Natural Gas Price	ϵ^{i3}	-0.304	0.133	-2.299
Weather Index	W	0.00049	0.00028	1.758
Income	I	-0.0532	0.0453	-1.173
Time Trend	T	-0.0926	0.073	-2.480
Serial Correlation Coefficient	ρ	-0.343	0.106	-3.224
Number of Observations = 78	Sample Period = 1962-72, 74, 75			
Sum of Squared Residuals $\sum (\epsilon_t^{im})^2$	=	10,753,700		
Standard Error of the Regression σ	=	397		
Coefficient of Determination R^2	=	.894		
Durbin-Watson Statistic	=	1.916		
Mean of Dependent Variable	=	3266		

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 8 *

Estimated Model - Standard Specification

Residential Sector

Kerosene Use

Variable	Parameter	Estimate	Standard Error	T-Statistic*
	C	-0.587	10.742	-0.055
Northern States Dummy	D	3.812	2.527	1.509
Energy Use Coefficient t-1	λ	0.576	0.082	7.016
Kerosene Price	ϵ^i	-2.442	5.877	-0.415
Electricity Price	ϵ^{i1}	0.275	0.609	0.453
Distillate Price	ϵ^{i2}	1.781	5.913	0.301
Natural Gas Price	ϵ^{i3}	2.253	0.609	3.697
Liquid Gases Price	ϵ^{i4}	-0.818	0.541	-1.512
Weather Index	W	0.00051	0.00103	0.490
Income	I	-0.402	0.267	-1.499
Serial Correlation Coefficient	ρ	0.236	0.110	2.149
Number of Observations = 78	Sample Period = 1962-72, 74-5			

Sum of Squared Residuals	$\Sigma \left(\epsilon_t^{im} \right)^2$	139,331,000
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Standard Error of the Regression $\sigma = 1431$

Coefficient of Determination $R^2 = 0.94$

Durbin-Watson Statistic = 2.03

Mean of Dependent Variable = 9365

$$* \text{ T-Statistic} = \frac{\text{Estimate}}{\text{Standard Error}}$$

Table 9 *

Estimated Model - Standard Specification

Commercial Sector

Electricity Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	19.045	4.329	4.398
Northern States Dummy	D	2.256	0.912	2.474
Energy Use Coefficient t-1	λ	0.658	0.049	13.261
Electricity Price	ϵ^i	-0.367	0.068	-5.419
Residual Price	ϵ^{i1}	0.0036	0.0301	0.119
Distillate Price	ϵ^{i2}	0.0370	0.0501	0.740
Natural Gas Price	ϵ^{i3}	0.164	0.034	4.815
Wage	ϵ^{iw}	0.468	0.124	3.776
Weather Index	W	-0.00125	0.00043	-2.875
Income	I			
Interest Rate	ϵ^{ir}	0.0471	0.0115	4.073
Serial Correlation Coefficient	ρ	-0.119	0.112	-1.058
Number of Observations = 78	Sample Period = 1962-72, 74, 75			
Sum of Squared Residuals $\sum \epsilon_t^{im^2}$	=	13626		
Standard Error of the Regression σ	=	14.16		
Coefficient of Determination R^2	=	0.99		
Durbin-Watson Statistic		1.86		
Mean of Dependent Variable		313		

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 10 *
Estimated Model - Standard Specification
Commercial Sector
Residual Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-145.5	130.4	-1.116
Northern States Dummy	D	- 21.70	30.95	-0.701
Energy Use Coefficient t-1	λ	0.819	0.079	10.392
Residual Price	ϵ^i	- 0.0912	0.229	-0.397
Electricity Price	ϵ^{ii}	0.609	0.415	1.468
Distillate Price	ϵ^{i2}	-0.757	0.455	-1.66
Natural Gas Price	ϵ^{i3}	-0.0043	0.273	-0.015
Wage Price	ϵ^{iw}	0.0202	0.949	0.021
Interest Rate	ϵ^{ir}	-0.121	0.091	-1.322
Weather Index	W	0.0091	0.0136	0.673
Time Trend	T	2.704	1.941	1.393
Serial Correlation Coefficient	ρ	0.019	0.113	0.168
Number of Observations = 78	Sample Period = 1962-72, 74, 75			
Sum of Squared Residuals $\sum (\epsilon_t^{im})^2$	=	8,966,921		
Standard Error of the Regression σ	=	366		
Coefficient of Determination R^2	=	0.95		
Durbin-Watson Statistic	=	2.00		
Mean of Dependent Variable	=	1377		

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 11 *

Estimated Model - Standard Specification

Commercial Sector

Distillate Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	3.074	23.011	0.133
Northern States Dummy	D	-3.270	5.618	-0.582
Energy Use Coefficient t-1	λ	0.961	0.017	54.92
Distillate Price	ϵ^i	0.0625	0.114	0.548
Electricity Price	ϵ^{i1}	-0.058	0.078	-0.731
Residual Price	ϵ^{i2}	-0.094	0.060	-1.556
Natural Gas Price	ϵ^{i3}	0.057	0.065	0.867
Wage	$\epsilon^{i\omega}$	-0.145	0.192	-0.752
Interest Rate	ϵ^{ir}	0.062	0.024	2.55
Weather Index	W	0.0013	0.0031	0.427
Serial Correlation Coefficient	ρ	-0.410	0.103	-3.972
Number of Observations = 72	Sample Period = 1962, 72, 74, 75			

Sum of Squared Residuals $\sum (\epsilon_t^{im})^2 = 737741$

Standard Error of the Regression $\sigma = 104$

Coefficient of Determination $R^2 = .98$

Durbin-Watson Statistic = 2.29

Mean of Dependent Variable = 1444

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 12 *

Estimated Model - Standard Specification

Commercial Sector

Natural Gas Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-0.0712	5.106	-0.014
Northern States Dummy	D	-2.340	1.578	-1.483
Energy Use Coefficient t-1	λ	0.772	0.067	11.402
Natural Gas Price	ϵ^i	-0.368	0.091	-4.032
Electricity Price	ϵ^{i1}	0.088	0.064	1.371
Residual Price	ϵ^{i2}	-0.053	0.053	1.006
Distillate Price	ϵ^{i3}	0.137	0.095	1.448
Wage	$\epsilon^{i\omega}$	0.158	0.179	0.882
Interest Rate	ϵ^{ir}	0.028	0.022	1.301
Weather Index	W	0.00012	0.00063	0.186
Serial Correlation Coefficient	ρ	-0.136	0.124	-1.101
Number of Observations = 64	Sample Period - 1962-72, 74, 75			
	Except Maine and Vermont : 1968-62, 74, 75			
Sum of Squared Residuals $\sum(\epsilon_t^{im})^2$	= 28084			
Standard Error of the Regression σ	= 22.8			
Coefficient of Determination R^2	= .98			

Durbin-Watson Statistic = 2.23

Mean of Dependent Variable = 298

* T-Statistic =

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 13*

Estimated Model - Standard Specification

Manufacturing Sector

Electricity Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	3.809	8.855	0.480
Northern States Dummy	D	3.320	1.139	2.916
Energy Use Coefficient t-1	λ	0.858	0.065	13.138
Electricity Price	ϵ^{i1}	-0.098	0.076	-1.288
Residual Price	ϵ^{i2}	-0.055	0.049	-1.112
Distillate Price	ϵ^{i3}	-0.153	0.124	-1.124
Natural Gas Price	ϵ^{i4}	-0.012	0.023	-0.519
Liquid Gases Price	$\epsilon^{i\omega}$	0.162	0.067	2.423
Wage	ϵ^{ir}	0.055	0.086	0.640

Interest Rate ϵ 0.0099 0.0163 0.606

Time 0.325 0.128 2.549

Serial Correlation Coefficient ρ -0.010 0.0113 -0.090

Number of Observations = 78 Sample Period = 1962-72, 74, 75

Sum of Squared Residuals $\sum (\epsilon_t^{im})^2 = 49966$

Standard Error of the Regression $\sigma = 27.3$

Coefficient of Determination $R^2 = .986$

Durbin-Watson Statistic 1.85

Mean of Dependent Variable 545

*T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 14*
Estimated Model - Standard Specification
Manufacturing Sector
Residual Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-14.955	63.273	-0.236
Northern States Dummy	D	15.601	14.350	1.087
Energy Use Coefficient t-1	λ	0.862	0.023	11.832
Residual Price	ϵ^i	-0.241	0.394	-0.610
Electricity Price	ϵ^{i1}	0.000	-	-
Distillate Price	ϵ^{i2}	0.186	1.202	0.155
Natural Gas Price	ϵ^{i3}	0.029	0.191	0.149
Liquid Gases Price	ϵ^{i4}	-0.085	0.595	-0.143
Coal Dummy	D^c	8.319	18.964	0.439
Wage	ϵ^{iw}	0.215	0.668	0.322
Interest Rate	ϵ^{ir}	0.120	0.158	0.762
Time Trend	T	-1.242	2.431	-0.511
Serial Correlation Coefficient	ρ	-0.072	0.112	-0.640
Number of Observations = 78	Sample Period = 1962-72, 74-75			

Sum of Squared Residuals $\sum \epsilon^2 = 16,251,600$

Standard Error of the Regression $\sigma = 493$

Coefficient of Determination $R^2 = .826$

Durbin-Watson Statistic = 1.892

Mean of Dependent Variable = 1435

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 15 *

Estimated Model - Standard Specification

Manufacturing Sector

Distillate Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	9.289	4.944	1.879
Northern States Dummy	D	-0.125	0.958	-0.130
Energy Use Coefficient t-1	λ	0.766	0.074	10.388
Distillate Price	ϵ^i	-1.470	0.621	-2.368
Electricity Price	ϵ^{i1}	-0.211	0.275	-0.768
Residual Price	ϵ^{i2}	0.380	0.259	1.466
Natural Gas Price	ϵ^{i3}	0.138	0.108	1.277
Liquid Gases Price	ϵ^{i4}	0.384	0.393	0.976
Wage	$\epsilon^{i\omega}$	-0.342	0.359	-0.952
Interest Rate	ϵ^{ir}	-0.031	0.085	-0.357
Serial Correlation Coefficient	ρ	-0.368	0.105	-3.493
Number of Observations = 78	Sample Period = 1962-72, 74, 75			
Sum of Squared Residuals $\sum (\epsilon_t^{im})^2$	=88960			
Standard Error of the Regression σ	= 86.2			
Coefficient of Determination R^2	= .717			

Durbin-Watson Statistic = 1.967

Mean of Dependent Variable = 132

* T-Statistic =

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 16 *

Estimated Model - Standard Specification

Manufacturing Sector

Natural Gas Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	51.835	19.773	2.622
Northern States Dummy	D	-17.998	5.523	-3.259
Energy Use Coefficient t-1	λ	0.465	0.135	3.444
Natural Gas Price	ϵ	- 0.048	0.107	-0.453
Electricity Price	ϵ^{i1}	- 0.288	0.267	-1.028
Residual Price	ϵ^{i2}	0.180	0.129	1.395
Distillate Price	ϵ^{i3}	- 1.890	0.607	-3.113
Liquid Gases Price	ϵ^{i4}	- 0.0014	0.175	-0.008
Wage	ϵ^{ω}	- 0.606	0.405	-1.495
Interest Rate	ϵ^r	0.023	0.043	0.540
Shift Term	$\epsilon^{1973 \ 75}$	28.575	10.578	2.201
Serial Correlation Coefficient	ρ	0.562	0.103	5.438

Number of Observations = 64 Sample Period = 1962-72, 74, 75
 Except Maine and Vermont :

Sum of Squared Residuals $\sum (\epsilon_t^{im})^2 = 113602$

Standard Error of the Regression $\sigma = 46.3$

Coefficient of Determination $R^2 = .979$

Durbin-Watson Statistic = 1.565

Mean of Dependent Variable = 414

* T-Statistic =

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

Table 17 *

Estimated Model - Standard Specification

Manufacturing Sector

Liquid Gases Use

Variable	Parameter	Estimate	Standard Error	T-Statistic*
	C	0.383	1.100	0.348
Northern States Dummy	D	0.101	0.186	0.544
Energy Use Coefficient t-1	λ	0.902	0.059	15.143
Liquid Gases Price	ϵ^i	0.267	0.293	0.909
Electricity Price	ϵ^{i1}	-0.270	0.312	-0.867
Residual Price	ϵ^{i2}	0.211	0.221	0.953
Distillate Price	ϵ^{i3}	-0.755	0.474	-1.595
Natural Gas Price	ϵ^{i4}	0.093	0.086	1.086
Wage	ϵ^{iw}	0.427	0.344	1.240
Interest Rate	ϵ^{ir}	0.045	0.344	1.240

Serial Correlation Coefficient	-	0.111	-1.744
--------------------------------	---	-------	--------

Number of Observations = 78 Sample Period = 1962-72, 74, 75

Sum of Squared Residuals $\sum (\epsilon_t^{im})^2 = 2773$

Standard Error of the Regression σ = 6.39

Coefficient of Determination $R^2 = 0.919$

Durbin-Watson Statistic = 1.964

Mean of Dependent Variable = 30.82

* T-Statistic =

$$* \text{ T-Statistic} = \frac{\text{Estimate}}{\text{Standard Error}}$$

Table 18 *

Estimated Model - Standard Specification

Manufacturing Sector

Kerosene Use

<u>Variable</u>	<u>Parameter</u>	<u>Estimate</u>	<u>Standard Error</u>	<u>T-Statistic*</u>
	C	-5.674	4.394	-1.291
Northern States Dummy	D	0.535	0.809	0.661
Energy Use Coefficient t-1	λ	0.566	0.088	6.407
Kerosene Price	ϵ	-6.401	11.235	-0.569
Electricity Price	ϵ^{i1}	2.236	1.158	1.931
Residual Price	ϵ^{i2}	-1.148	1.059	-1.084
Distillate Price	ϵ^{i3}	4.856	10.648	0.456
Natural Gas Price	ϵ^{i4}	1.495	0.499	2.996
Liquid Gases Price	ϵ^{i5}	0.689	1.637	0.421
Wage	$\epsilon^{i\omega}$	0.237	1.290	0.184
Interest Rate	ϵ^{ir}	0.476	0.322	1.476

Serial Correlation Coefficient

ρ

-0.349

0.106

-3.289

Number of Observations = 78

Sample Period = 1962-72, 74, 75

Sum of Squared Residuals $\sum (\epsilon_t^{im})^2 = 63120$

Standard Error of the Regression $\sigma = 30.7$

Coefficient of Determination $R^2 = 0.710$

Durbin-Watson Statistic = 1.991

Mean of Dependent Variable = 54.7

* T-Statistic =

* T-Statistic = $\frac{\text{Estimate}}{\text{Standard Error}}$

TABLE 19

Estimated Parameters From Alternate Specifications

Sector/Energy Form Modelled	T^*	D^c	λ^r **
Residential:			
Electricity	0.0934 (.0665)***	n. e.	0.00207 (.00675)
Distillate	-0.3167 (.2927)	n. e.	0.0108 (.0121)
Natural Gas	0.0134 (.1503)	n. e.	-0.0255 (.0102) +
Liquid Gases	-0.0926 (.0373)+	n. e.	0.0747 (.0308) +
Kerosene	-0.1224 (.1779)	n. e.	0.0252 (.0385)
Commercial			
Electricity	-0.0868 (.0698)	n. e.	-0.00633 (.0168)
Residual	2.704 (1.941)	n. e.	0.0759 (.0689)
Distillate	0.496 (0.435)	n. e.	0.00253 (0.01747)
Natural Gas	0.156 (0.167)	n. e.	0.107 (0.033) +
Manufacturing			
Electricity	0.325 (0.128)+	2.427 (0.808)+	0.0995 (.0560) +
Residual	-1.242 (2.432)	-4.936 (15.716)	-0.00634 (0.102)
Distillate	0.0298 (0.133)	0.0256 (1.010)	0.0718 (0.0374)
Natural Gas	0.758 (0.761)	-0.852 (1.750)	0.161 (0.053) +
Liquid Gases	-0.012 (0.026)	n. e.	0.0956 (0.0496)+
Kerosene	-0.154 (0.123)	n. e.	0.0133 (0.188)

* In models where a time trend or the coal dummy have not been included in the standard specification, alternate specifications were estimated using those variables, and the results are presented here. Whenever estimated parameters are significantly different from zero at a 10% level of significance and for some other cases as well, these variables have been included in the standard specification

** A model assuming $\lambda = \lambda_0 + \lambda^r$ (Cost of Borrowing) was also estimated to examine whether the lag structure estimated is sensitive to interest rate changes. The estimates of λ^r and their standard errors are presented here.

*** Standard errors of parameter estimates are reported in parentheses after the parameter estimates

n.e. - not estimated

+ - Significantly different from zero at a 10% level of significance

Table 20 *

Tests of Structural Shifts in Models
Due to the Energy Crisis
(Behavioral Change after 1975)

<u>Sector/Energy Form Modelled</u>	<u>Constant Shift*</u> <u>t-statistic</u>	<u>Coefficient Shifts**</u> <u>F-Statistic</u>
Residential		
Electricity	1.469	1.848
Distillate	-1.877 +	2.011 ++
Natural Gas	0.092	1.768
Liquid Gases	-2.570 +	1.049
Kerosens	-0.806	1.434
Commercial		
Electricity	-1.362	1.900
Residual	0.876	0.736
Distillate	0.889	0.672
Natural Gas	0.369	0.656
Manufacturing		
Electricity	0.051	1.144
Residual	2.192 +	0.834
Distillate	-1.691 +	0.309
Natural Gas	+2.701 +	1.391
Liquid Gases	0.128	1.093
Kerosene	-0.216	0.916

* A model was estimated including a dummy variable which allows the constant C to change after 1973. That specification allows a translation of the estimated behaviors, due to energy crisis effects. The test run is on the significance of the difference in those two constants, or the significance of the coefficient for the dummy variable. Where a significantly large t-statistic is obtained, the hypothesis that the constant did not change is rejected; otherwise the stability of the constant term is accepted.

** The test is based on the hypothesis that all coefficients are the same before and after 1973. To carry out this test, the standards specification for each model was estimated for data prior to 1973 and for data after 1973, separately. The F-statistic used in this test is as follows:

$$\text{Test statistic: } \frac{\left(\frac{\sum (\epsilon_{t,c}^{im})^2}{c} - \frac{\sum (\epsilon_{t,b}^{im})^2}{b} - \frac{\sum (\epsilon_{t,a}^{im})^2}{a} \right)}{\frac{\left(\frac{\sum (\epsilon_{t,b}^{im})^2}{b} + \frac{\sum (\epsilon_{t,a}^{im})^2}{a} \right)}{N-2k}}$$

Where: $\sum (\epsilon_{t,c}^{im})^2$ is the sum of squared residuals estimated using all data and imposing the constraint that coefficients are equal before and after 1973.

$\sum (\epsilon_{t,b}^{im})^2$ is the sum of squared residuals estimated using data prior to 1973.

$\sum (\epsilon_{t,a}^{im})^2$ is the sum of squared residuals estimated using 1974-75 data.

If the constraint is correct, and there is no structural shift, a statistic of zero is expected. A significantly large F-statistic is evidence of structural change after 1973.

+ Significantly different from zero at a 10% level of significance.

++ Significantly different from zero at a 5% level of significance.

Table 21

Comparisons of Estimated Energy Demand Elasticities
with Previous Results *

Sector/Energy Form	Price of:	Estimates		F.E.A.**	Baughman et al. ***	
		SR	LR	LR	SR	LR
Residential						
Electricity	Electricity	-0.240 (0.034)	++ -1.55	-1.011	-0.187	-1.003
	Distillate	-0.061 (0.032)	-0.393	0.120	0.011	0.046
	Natural Gas	0.009 (0.026)	0.058	0.422	0.045	0.170
	Liquid Gases	0.062 (0.016)	0.400	--	--	--
Distillate	Distillate	-0.120 (0.062)	-0.591	-0.515	-1.12	-1.79
	Electricity	-0.001 (0.044)	-0.004	0.116	0.007	0.157
	Natural Gas	0.019 (0.034)	0.082	0.068	0.040	0.185
	Liquid Gases	-0.046 (0.060)	-0.200	--	--	--
Natural Gas	Natural Gas	-0.078 (0.047)	-1.418	-0.817	-0.15	-1.009
	Electricity	0.077 (0.033)	1.400	0.316	0.006	0.168
	Distillate	-0.049 (0.055)	-0.891	0.054	0.011	0.055
	Liquid Gases	0.045 (0.045)	0.818	--	--	--
Liquid Gases	Liquid Gases	-0.308 (0.179)	-3.347	--	--	--
	Electricity	-0.347 (0.204)	-3.771	--	--	--
	Distillate	1.781 (5.913)	4.200	--	--	--
	Natural Gas	-0.304 (0.133)	3.304	--	--	--
Kerosene	Kerosene	-2.442 (5.871)	-5.759	--	--	--
	Electricity	0.275 (0.609)	0.649	--	--	--
	Distillate	1.781 (5.913)	4.200	--	--	--
	Natural Gas	2.253 (0.609)	5.313	--	--	--
	Liquid Gases	-0.818 (0.541)	-1.929	--	--	--

Table 21 (continued)

Sector/Energy Form	Price of;	Estimates		F.E.A.**		Baughman et al. ***	
		SR	LR	LR	SR	LR	LR
Commercial							
Electricity	Electricity	-0.367 (0.068)	1.073	-1.011	-0.187	-1.003	
	Residual	0.0036 (0.030)	0.010	0.120	0.011	0.046	
	Distillate	0.037 (0.050)	0.108	0.422	0.045	0.170	
	Natural Gas	0.164 (0.034)	0.480	--	--	--	
Residual	Residual	-0.091 (0.229)	-0.502	--	--	--	
	Electricity	0.609 (0.415)	3.364	--	--	--	
	Distillate	-0.757 (0.455)	-4.182	--	--	--	
	Natural Gas	-0.004 (0.273)	-0.022	--	--	--	
Distillate	Distillate	0.063 (0.114)	1.615	-0.515	-1.12	-1.79	
	Electricity	-0.058 (0.078)	-1.487	0.116	0.007	0.157	
	Residual	-0.049 (0.060)	-2.410	--	0.040	0.185	
	Natural Gas	0.057 (0.065)	1.462	--	--	--	
Natural Gas	Natural Gas	-0.368 (0.091)	-1.614	0.817	-0.15	-1.009	
	Electricity	0.088 (0.064)	0.386	0.316	0.006	0.168	
	Residual	-0.053 (0.053)	0.232	--	--	--	
	Distillate	0.137 (0.095)	0.601	0.054	0.011	0.055	

Table 21 (continued)

Sector/Energy Form	Price of:	Estimates		F.E.A.**		Baughman et al.***	
		SR	LR	LR	SR	SR	LR
Manufacturing							
Electricity	Electricity	-0.098 (0.078)	-0.690	-0.330	-0.11	-0.11	-1.28
	Residual	-0.055 (0.049)	-0.387	0.038	0.01	0.01	0.13
	Distillate	-0.153 (0.124)	-1.077	--	--	--	--
	Natural Gas	-0.012 (0.023)	-0.084	0.136	0.06	0.06	0.73
	Liquid Gases	0.162 (0.062)	1.141	--	--	--	--
Residual	Residual	-0.241 (0.394)	-1.746	-1.00	-0.11	-0.11	-1.32
	Electricity	0.0 ()	0.0	0.449	0.03	0.03	0.34
	Distillate	0.186 (1.202)	1.347	--	--	--	--
	Natural Gas	0.029 (0.191)	0.210	0.271	0.06	0.06	0.75
	Liquid Gases	-0.085 (0.595)	-0.616	--	--	--	--
Distillate	Distillate	-1.470 (0.621)	-6.282	--	--	--	--
	Electricity	-0.211 (0.275)	-0.902	--	--	--	--
	Residual	0.380 (0.259)	1.624	--	--	--	--
	Natural Gas	0.138 (0.108)	0.589	--	--	--	--
	Liquid Gases	0.384 (0.393)	1.641	--	--	--	--
Natural Gas	Natural Gas	-0.048 (0.102)	-0.089	0.093	-0.07	-0.07	-0.81
	Electricity	-0.288 (0.267)	-0.538	0.036	0.03	0.03	0.34
	Residual	0.180 (0.129)	0.336	0.062	-0.01	-0.01	0.14
	Distillate	-1.890 (0.0607)	-3.582	--	--	--	--
	Liquid Gases	-0.0014(0.775)	-0.0026	--	--	--	--

Table 21 (continued)

Sector/Energy Form	Price of:	Estimates		F.E.A.**		Baughman et al.**	
		SR	LR	LR	SR	SR	LR
Manufacturing (cont'd)							
Liquid Gases	Liquid Gases	-0.267 (0.293)	2.724	--	--	--	--
	Electricity	-0.270 (0.312)	-2.755	--	--	--	--
	Residual	0.211 (0.221)	2.153	--	--	--	--
	Distillate	-0.755 (0.474)	-7.704	--	--	--	--
	Natural Gas	0.093 (0.086)	0.949	--	--	--	--
Kerosene	Kerosene	-6.401(11.235)	14.748	--	--	--	--
	Electricity	2.236 (1.158)	5.152	--	--	--	--
	Residual	-1.148 (1.059)	2.645	--	--	--	--
	Distillate	4.856(10.648)	11.188	--	--	--	--
	Natural Gas	1.495 (0.499)	3.445	--	--	--	--
Liquid Gases	0.689 (1.637)	1.094	--	--	--	--	

Table 21

- * Previous estimates are of U.S. rather than New England parameters. Hence, comparisons of these estimates and previous results constitute a test of the relevance of U.S. parameters in a New England model.
- ++ Standard errors for the short run (one-year) elasticity estimates are reported in parentheses after the estimates.
- ** Parameters used in the PIES model created by the Federal Energy Administration. These are the basis for the parameters presently being used in the NEME model.
- *** Residential and commercial sectors are aggregated in the estimations of Baughman and Joskow (1975), so that the parameters estimated are identical for those two sectors. Industrial sector parameters are reported in Baughman and Zerhoot (1975).

Table 22

Derived Demand Elasticities to be Used in
the New England Macroeconomic Energy Model

<u>Sector/Input</u>	<u>Price</u>	<u>5-year Elasticity*</u>	<u>5-year Lag Term**</u>
<u>Residential</u>			
Electricity	Electricity	-0.985	0.364
	Distillate	0.000	--
	Natural Gas	0.037	0.364
	Liquid Gases	0.254	0.364
Distillate	Distillate	-0.412	0.207
	Electricity	0.000	--
	Natural Gas	0.065	0.207
	Liquid Gases	0.000	--
Natural Gas	Natural Gas	-0.408	0.712
	Electricity	0.403	0.712
	Distillate	0.000	--
	Liquid Gases	0.235	0.712
Liquid Gases	Liquid Gases	-1.472	0.560
	Electricity	0.000	--
	Distillate	0.000	--
	Natural Gas	0.000	--
Kerosene	Kerosene	-5.549	0.037
	Electricity	0.000	--
	Distillate	0.000	--
	Natural Gas	0.000	--
	Liquid Gases	0.000	--

Table 22 (cont'd)

<u>Sector/Input</u>	<u>Price</u>	<u>5 Year Elasticity*</u>	<u>5 year Lag Term**</u>
Commercial			
Electricity	Electricity	-0.986	0.082
	Residual	0.010	0.082
	Distillate	0.099	0.082
	Natural Gas	0.441	0.082
	Labor	1.257	0.082
	Capital	0.126	0.082
Residual	Residual	-0.351	0.302
	Electricity	0.000	--
	Distillate	0.000	--
	Natural Gas	0.000	--
	Labor	0.077	0.302
	Capital	0.000	--
Distillate	Distillate	-0.169	0.788
	Electricity	0.000	--
	Residual	0.000	--
	Natural Gas	0.000	--
	Labor	0.000	--
	Capital	0.338	0.788
Natural Gas	Natural Gas	-1.272	0.212
	Electricity	0.304	0.212
	Residual	0.000	--
	Distillate	0.474	0.212
	Labor	0.546	0.212
	Capital	0.097	0.212

Table 22 (continued)

<u>Sector/Input</u>	<u>Price</u>	<u>5-Year Elasticity*</u>	<u>5-Year Lag Term**</u>
Manufacturing			
Electricity			
	Electricity	-0.415	0.399
	Residual	0.000	--
	Distillate	0.000	--
	Natural Gas	0.000	--
	Liquid Gases	0.000	--
	Labor	0.233	0.399
	Capital	0.042	0.399
Residual			
	Residual	-1.030	0.410
	Electricity	0.000	--
	Distillate	0.795	0.410
	Natural Gas	0.124	0.410
	Liquid Gases	0.000	--
	Labor	0.919	0.410
	Capital	0.513	0.410
Distillate			
	Distillate	-5.013	0.202
	Electricity	0.000	--
	Residual	1.295	0.202
	Natural Gas	0.471	0.202
	Liquid Gases	0.000	--
	Labor	0.000	--
	Capital	0.000	--
Natural Gas			
	Natural Gas	-0.089	0.010
	Electricity	0.000	--
	Residual	0.000	--
	Distillate	0.000	--
	Liquid Gases	0.000	--
	Labor	0.000	--
	Capital	0.043	0.010
Liquid Gases			
	Liquid Gases	0.000	1.000
	Electricity	0.000	--
	Residual	0.000	--
	Distillate	0.000	--
	Natural Gas	0.000	--
	Labor	0.000	--

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THE NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

The Economic Impact of Alternative Energy Policies
In A
Macroeconomic Model of New England

Appendix V

Energy Scenario Simulations

I. Introduction

Events in energy markets in recent years, including both dramatically increasing prices and shortages, have made policy makers painfully aware of the nation's vulnerability in that arena. Congress is presently debating the adoption of a comprehensive energy policy which would use, for the most part, price signals and market interventions to encourage energy conservation. The potential economic consequences of such policies have concerned regional policy makers, particularly in New England, where energy prices have been high historically and where there is a pronounced dependence on energy imports from both abroad and elsewhere in the United States. That concern has encouraged New England policy makers to examine the economic and energy market impacts of alternative scenarios and potential responses. The research documented in this report represents a culmination of that concern for the Massachusetts Energy Office, which has supported this examination of the interrelationships between New England's energy needs and economic outcomes.

In earlier Tasks of this project, we have developed a New England Macroeconomic Energy Model (NEME), which is used to examine the consequences of alternative energy supply and macroeconomic demand scenarios for energy demand and economic outcomes in the New England region. That model is fashioned after the demand-driven Input-Output planning models in the development economics literature. Such models have been used extensively throughout the world, and particularly in developing and socialist countries, to assist in comprehensive economic planning. They are well suited to the examination of macroeconomic and energy scenarios when designed explicitly for that purpose. Such a model was developed for the U.S. by Hudson and Jorgenson and

is presently being utilized in examining national energy policies at Brookhaven National Laboratory. The NEME model was designed with that structure in mind and recognizes the particular problems faced by regional analysts.

The detailed structure of the NEME model has been documented in the Task I Final Report of this project, with revisions to that structure presented in the subsequent reports. Abbott (1978) has discussed the advantages and limitations of this model structure elsewhere. It is important to remind the reader here that the NEME model is based on an Input-Output framework, with aggregate demand set exogenously and with the derived demand for energy and labor then also determined endogenously from production patterns and input prices. The model is also designed to be flexible, so that the analyst can impose or relax as many assumptions as necessary.

In this report, simulations of the New England economy utilizing the NEME model are described and compared. Those simulations represent alternative economic and energy scenarios, and so provide a basis for projection of New England's energy needs and their effect on economic outcomes, as well as projections of the consequences of alternative technological and policy options. In these simulations, energy supply, technological, and macroeconomic demand scenarios are assumed, and the details of energy demand plus certain important economic consequences - unemployment, price effects of energy costs, and production and income levels - are projected.

Fifteen simulations, or alternative scenarios, which examine four categories of possibilities, will be described in this report. The first set of simulations will be used to prepare a base projection case. These will include a simple extrapolation of 1974 energy-use patterns to 1980 and 1985, followed by examination of exogenously-forced conservation.¹ The

information from these scenarios is then used with new behavior parameters, describing the response of sectoral energy-use patterns to changes in sectoral energy prices, to determine a base projection case. These new behavioral parameters were estimated by Abbott and Lutostanski and are presented in the Task III Final Report. In order to investigate the consequences of these behavioral parameters, the base projection was also simulated using the parameters and functional form used in the U.S. Department of Energy's PIES model (Project Independence Evaluation System, Documentation), and previously used in NEME. The second category of simulations investigates the consequences of alternative projections of economic conditions and particularly alternative assumptions on aggregate economic growth. These scenarios examine more pessimistic and more optimistic assumptions than those utilized in the base case, as estimated by independent economic forecasters. The third set of simulations examine alternative projections of energy prices to the region. These will measure the New England economy's response to various world energy supply situations as well as the possibility of higher energy prices resulting from government policies. Higher price scenarios will be simulated using both the new behavioral parameters prepared by Abbott and Lutostanski, and the DOE/PIES parameters again to investigate the consequences of these alternative behavioral assumptions. In the final set of simulations, alternative technological assumptions will be imposed on the base projections. These will include investigation of more extensive use of coal by the manufacturing sector, use of solar energy by residential and commercial users, and adoption of cogeneration technologies by manufacturing industries.

The following section of this report examines in more detail the assumptions relevant to each of the scenarios examined. Tables documenting specific inputs to simulations are presented in Appendix A. For more detail on the description of the base economy (New England in 1974) from which projections are made, the Task I Final Report for this project should be consulted. That section will be followed by a discussion of the results obtained for each of the scenarios simulated. That discussion will examine the resulting energy demand, economic outcomes, and the important mechanisms which brought about those outcomes. In Appendix B, Tables reporting the important results obtained for each simulation case are presented. In addition, we will provide to the Massachusetts Energy Office a copy of the computer outputs obtained for each simulation case.²

II. Simulation Inputs

Overview of Inputs

For each of the simulations in this report, a set of New England economic parameters was pre-specified for the years 1974, 1980 and 1985. The 1974 data for New England remains unchanged throughout the simulations. This data was documented in an earlier part of this project. The input data for 1980 and 1985 represent a range of projections made by interested analysts that have been adapted for use in this model. These exogenously specified inputs fall into four basic categories.

First, projections of demographics, real wages, productivity, product export levels, and area income form a set of macroeconomic growth parameters. The Data Resources, Inc. (DRI) long-term growth forecasts of September, 1977 have been reduced slightly so that they apply to the New England area. These

revisions were suggested by the slower growth exhibited by the region in 1974 through 1977, and the slower expected regional growth reflected in the Massachusetts model projections (Treyz et al.). The "base case" growth parameters thus correspond to a New England version of DRI's TRENDLONG. The "low growth" scenario represents a New England version of DRI's CYCLELONG, and the "high growth" scenario corresponds to a New England version of DRI's CEASPIRIT.

Second, projections of real energy prices for all fossil fuels to all of the production sectors have been culled from DOE/PIES projections. The DOE/PIES model attempts to integrate energy supply and demand conditions for the United States and determine their effects on energy prices and economic activity. Of course, New England energy prices differ substantially from national averages; these differences have been reflected in the New England energy input prices used in this report. The "base case" prices embody an average energy demand and supply as foreseen by the Department of Energy, a trend toward equalization of energy prices charged to different sectors, and a movement towards equalization of domestic and world oil prices. As the Department of Energy (Project Independence Evaluation, Report to Congress) points out,

An important assumption influencing the projection of energy supply is the price of imported petroleum. Generally, the higher the price, the more domestic energy resources become economic. Assuming "current practices", most of the projection series embody the assumption of a constant real price of imported oil (at \$15.32 per barrel in 1978 dollars). However, an analysis of future world energy supply and demand reveals that upward pressures on world oil prices could develop during the decade of the 1980's. From a contingency planning standpoint, such price increases constitute an important exception to the "current practices" assumption. To illustrate the effects of such an eventuality, an alternative assumption termed "rising world oil prices" was developed. In this case, world prices in real terms are held constant (as before) through 1979, then assumed to increase at the rate of 5 percent through the year 1990.

These higher imported oil prices help create the background for the "high price" scenario; however, real energy price increases in New England are not quite as dramatic as this might suggest. The "base case" already represents a slow rise in real energy prices; the "high price" scenario accelerates that rise so that by 1985, real oil prices are approximately 15.6% higher than in the "base case". For comparison purposes, a "low price" scenario was also pursued. Here, the real prices of New England fossil fuels were maintained at their 1978 levels through 1980. These 1978 prices were drawn from Platt's Oilgram, the heating oil price monitoring surveys of the Massachusetts Energy Office, and recent issues of Retail Prices and Indices of Fuels and Utilities. In this "low price" case, between 1980 and 1985 real oil prices for the region were rolled one-tenth of the way back toward their 1974 levels (see Appendix A-1, attached).

Third, the price of electricity within the region is endogenously determined in the model. Total utility revenues must cover the utility expenditures for fuel, labor, and other variable costs, and still provide a fair return on generation and transmission capital. The "base case" attempts to embody the planned additions to and conversions of capital, and their probable effects on capital charges. These charges and capacities must be pre-specified (See Appendix A-1). The "high price" scenario reflects higher fuel and new-construction costs, while the "low price" scenario reduces only fuel costs. In some instances, assumptions concerning the addition of base-load capacity were altered - these are detailed in Appendix A-1.

Finally, some non-price adjustments to fuel-use patterns are contained in the model. These take the form of forced conservation of

fuels, or time trends increasing the use of electricity. Forced fuel savings are imposed in the "conservation" runs. These reductions in energy demand are applied to all of the fuels by a production sector. Forced conservation also mirrors the federally mandated increased fuel efficiency for the residential transportation fleet. The exogenous increase in electricity use is another matter. Non-price-induced increases in electricity use (per unit of output) have two causes. First, the use of electricity would continue to expand even if electricity prices did not fall, incomes did not rise, and the number of households and the amount of economic output did not grow. However, the authors have previously estimated this time trend to be very small. It is virtually non-existent in the commercial sector, adds eight-ninths of one percent to the manufacturing sector's demand each year, and adds one-half of one percent to residential electricity demand each year. Moreover, for each percent of rise in a household's real income, residential electricity use rises approximately one-half of one percent. Since the model incorporates an income elasticity of only 0.2 for residential energy demand, the extra increases in electricity use resulting from real income growth (per household) were added exogenously through the residential electricity time trend. It should be noted that the size of the time trend for electricity demand depends on the mathematical form of the demand equation, and the size of the income elasticity. In the DOE/PIES two-step energy demand equation, a substantially greater time trend is used.

Simulation Inputs - Detailed

A simple extrapolation - "EXTRAP" (Appendix A-2)

This simulation holds energy use per-unit-of-output fixed at 1974 levels while economic output and area income continue to expand. National forecasts show that a real per annum growth rate of 3.746% is appropriate for the United States economy for the years 1974 through 1980. Beyond 1980, it is probable that national output will grow at 3.65% per year. Projected New England growth rates are somewhat lower. This slower growth is caused by less population growth and a slower recovery from the past recession.

	<u>1974-80 Growth Rate</u>	<u>1980-85 Growth Rate</u>
<u>New England Real:</u>		
Disposable Income	3.500%	3.500%
G+E-M (Export demand levels)	3.700%	3.500%
Labor Force	1.689%	1.620%
Wage Rate	1.500%	1.500%

Real export demand grows slightly faster than the rest of output as government demand becomes a larger part of total production. Real income growth is fostered by growth in the labor force and worker productivity. The remainder of the real income growth reduces the unemployment rate or is soaked up by higher regional prices.

While energy-use patterns will not adjust in response to higher energy prices, some exogenous increase in electricity use is included. Further, it should be noted that the sectoral output mix of final demand will adjust in response to varied sectoral output price increases.

20% Conservation - "CON20" (Appendix A-3)

The hidden capacity for energy conservation and the associated increase in capital costs have been the focus of numerous engineering studies - it is possible to reduce energy demand if the capital stock is upgraded. This "conservation" scenario incorporates Massachusetts Energy Office estimates of conservation and annualized capital costs. In essence, it states that many conservation investments which could achieve quick paybacks are available. Here, these investments are undertaken and the costs are levelized over the life of the capital equipment - which is exceedingly long. It is believed that cost reductions will foster economic expansion.

In the commercial sector, it is assumed that an investment achieving a 10% reduction in energy demand could pay itself back in 2 years; further investment made to achieve 20% reduction could pay itself back in 4 years. These assumptions embody the belief that some "easy" or costless reductions in energy demand were already achieved by 1974. In this scenario, the commercial sector will achieve a 20% reduction in energy demand by 1985. The total cost of this conservation is approximately \$1.7 billion in 1974 dollars. Payments to capital for this sector will be increased to allow an annual 5% real return (after taxes) on this investment.

Less is known about the increased capital costs associated with industrial energy conservation. In this scenario, the industrial sector is to achieve a 16% energy demand reduction by 1985. It is assumed that this is achieved with investments that on the average could pay themselves back in 5 years. This represents an investment of 1.33 billion (1974)

dollars. Payments to capital for this sector will be increased to allow an annual 5.2% real return (after taxes) on this investment.

In the residential sector, a 20% reduction in energy demand is to be achieved by 1985. The total capital cost is estimated to be 0.9 billion (1974) dollars. Residential savings in fuel costs, in this model, will in effect increase the consumers' demand for all forms of real output. Of course, part of the increased industrial and commercial output will take the form of conservation materials and services.

Price-induced conservation in the transportation sectors has been included exogenously in this simulation. This will insure that demand will not inordinately shift to the manufacturing and commercial sectors, as it would if there were conservation only in those sectors.

30% Conservation - "CON30" (Appendix A-4)

Similarly, in this simulation, more conservation investments which could achieve longer paybacks are undertaken. These higher investment costs are levelized over the extremely long life of the capital equipment. It is believed that cost reductions will be passed along to the consumer and foster economic expansion. Again, Massachusetts Energy Office estimates of capital costs are incorporated.

For the commercial sector, 30% reduction in energy demand will be achieved by 1985. The investment needed to bring conservation from 20% to 30% could achieve a 6-year payback. This represents another 1.7 billion (1974) dollar investment. This additional investment earns an annual 10% real return (after taxes).

In the industrial sector, a 20% reduction in energy demand will be achieved by 1985. The investment needed to bring conservation from 16% to 20% could achieve a 5.3-year payback. This represents another 0.35 billion (1974) dollar investment. This additional investment earns an annual 10% real return (after taxes).

Residential energy demand will achieve a 30% reduction by 1985. The increased savings in residential fuel costs will increase the demand for all forms of real output. A greater part of the increased industrial and commercial output will take the form of conservation materials and services.

What would ordinarily be price-induced conservation in the transportation sectors has been included exogenously in this simulation, as well.

30% Conservation: No Seabrook - "CON30NS" (Appendix A-5)

The conservation and capital cost assumptions of the previous simulation are maintained. However, dwindling electricity demand as a result of heavy conservation efforts have made the planned addition of one nuclear plant seem unnecessary. This base capacity and its capital charge are eliminated in this simulation. The changes are outlined in Appendices A-1 and A-5.

Base Case - "BASE" (Appendix A-6)

The macroeconomic growth projections of the extrapolation and the conservation scenarios are still maintained. However, the only exogenously

specified conservation corresponds to the federally mandated increase in the fuel efficiency of the residential transportation fleet. All other energy-use adjustments (and additional adjustments in residential transportation) are price-induced. This simulation outlines the response that might be expected from "normal behavioral parameters".

This simulation uses the price-elasticity and lagged response mechanisms estimated by the authors (Abbott and Lutostanski, 1978) for use in this model for manufacturing, services, and residential energy services. Energy use of each fuel by each of those sectors separately responds to changes in the price of that fuel and the price of available substitutes. Transportation models utilize DOE/PIES parameters.

As before, the price of electricity is endogenously determined, Seabrook is included in the 1985 base capacity, and the "BASIC" price projections for fuels (as outlined in Appendix A-1) are used.

Further, the estimates of the capital costs of conservation (as outlined in the conservation runs) are automatically included. For example, should the commercial sector happen to achieve a 20% reduction in overall energy demand by 1985, capital income to that sector will expand to previously specified levels. If it achieves only part of that conservation, capital income will increase to cover only that partial investment.

FEA Base Case - "FEABS" (Appendix A-7)

The only differences between the "BASE" simulation and this one occur as a result of using a different mechanism to adjust energy use to prices. This simulation uses the "two-step" model of energy demand determination (DOE/PIES), its own price elasticities, its own lagged adjustment

mechanism, and its greater time trend in electricity use. The basic macro-economic and energy price projections are maintained.

High Economic Growth - "HIGRO" (Appendix A-8)

More optimistic economic growth is foreseen through 1980 in this version of the macroeconomic inputs. Real growth for New England increases through 1980, then slacks off through 1985. Still, real area income is substantially (2%) higher in 1985 than in the base case.

For each one percent change in the growth rate in area income, roughly one-third corresponds to a change in productivity, another third to a change in the labor force, and the remaining third to a change in the unemployment situation.

	<u>1974-80 Growth Rate</u>	<u>1980-85 Growth Rate</u>
<u>New England Real:</u>		
Disposable Income	4.070	3.210
G+E-M (Export demand levels)	4.270	3.210
Labor Force	1.812	1.552
Wage Rate	1.690	1.403

The "two-step" model of energy demand (DOE/PIES) is not used in this run; instead, the direct elasticity formulation and the newly estimated NEME parameters control energy-use adjustment (as in BASE, not FEABS). The only change in real energy prices (compared to BASE) will occur endogenously in the electric sector.

Low Economic Growth - "LOGRO" (Appendix A-9)

Again, the Abbot-Lutostanski parameters control energy-use adjustment; and the only change in real energy prices will be produced endogenously in

the electric sector. The exogenous macroeconomic inputs are more pessimistic. Regional economic growth is slowed only slightly through 1980, but then drops off markedly through 1985. By 1985, real area income has been reduced 3.5 % below the base projection.

	<u>1974-80 Growth Rate</u>	<u>1980-85 Growth Rate</u>
<u>New England Real:</u>		
Disposable Income (GRP)	3.452%	2.830%
G+E-M (Export demand levels)	3.652	2.830
Labor Force	1.675	1.407
Wage Rate	1.484	1.277

High Energy Prices - "HIPRI" (Appendix A-10 or A-1)

As world energy markets tighten, world oil prices (and the prices of fossil fuel substitutes) might increase dramatically in real terms. This computer simulation will outline the changes in energy use that could be expected to occur in response to these higher prices. It is also possible that federal policy will bring about higher real energy prices. In this simulation, the higher fuel prices of Appendix A-1 are used while the basic macroeconomic real growth patterns are reinstituted.

Costs to the electric sector are increased in more than one manner. First, the prices paid for oil and coal increase substantially. Second, the price of nuclear fuel increases to a nominal 1985 level of 1.5¢/kWh (the base case 1985 nominal price was 0.916¢/kWh). And finally, whereas in the basic calculations the 1985 nominal price of newly constructed nuclear plant capacity (exclusive of transmission and distribution equipment) was \$1135/kW; this cost is increased to \$2270/kW. Similarly, the nominal 1985 cost of new transmission equipment for this nuclear plant has

has been increased from \$834.75/kW to \$1669.50/kW.

It is the judgement of the Massachusetts Energy Office that these energy prices and capital costs constitute a reasonable upper realm for New England. This implies that the price-induced conservation that is achieved under these circumstances is the limit to what one might expect given normal adjustment patterns.

FEA High Price - "FEAHP" (Appendix A-10 or A-1)

The same high energy prices and increased electric sector capital costs are maintained. Macroeconomic activity in the region is anticipated to grow at the basic rates. However, the "two-step" energy demand model (DOE/PIES) now gives its estimate of the price-induced changes in energy demand. This is the second and last instance in which this energy demand model is used.

High Price, Low Path - "HIPLOP" (Appendix A-10 or A-1)

In this case, energy prices and nuclear plant capital costs reach their high 1985 levels as previously outlined, but a deceptively low path is followed. Real energy prices remain constant at 1978 levels through 1980. This means that the "low" prices are used for 1980 and the "high" prices are used for 1985 (see Appendix A-1).

If it is wondered whether temporarily low energy prices can lull the economy into inactivity and thus cause more economic disruption than would steadily increasing real energy prices, then the results of this simulation should be compared to "HIPRI".

Low Energy Prices - "LOPRI" (Appendix A-10 or A-1)

What would be the energy use pattern in 1985 if real energy prices remained constant at 1978 levels through 1980, and then rolled part of the way back to 1974 levels? The energy-use pattern fostered by the adjustment to lower real prices probably exhibits greater oil dependence while economic growth is undoubtedly improved.

This scenario keynotes the disruptive economic effects of rising real energy prices in New England.

Cogeneration - "COGEN" (Appendix A-11)

In this simulation, the manufacturing and commercial services sector installs 1679 megawatts of electricity-generating equipment by 1985. With this electric equipment on site, transmission losses are reduced and the steam by-product can also be better put to use. The manufacturing sector will generate 34.06 trillion Btu's of electricity using this technology. Half of this electricity can be used directly on site; the other half must be resold to the electric utility for redistribution. The commercial services sector will generate only 6.06 trillion Btu's of electricity using this technology; 60% of this must be sold to the electric utility for redistribution.

A more detailed description of the equipment is given in Appendix A-11. These data were furnished by the Massachusetts Energy Office.

It is assumed that 10% of the electricity which is returned to the utility will be lost in transmission and distribution before it is resold. Transmission losses for other forms of electricity production are already

implicit in load factors or input-output coefficients in the model. Since this cogenerated electricity which is returned must use the utility distribution equipment, it must be priced so that both the utility and the cogenerator may idle utility-owned generators and make utility conversion to coal seem less urgent. This less extensive coal use is embodied in the simulation. Keeping this in mind, it was estimated that the utility would re-purchase the electricity from the cogenerator at roughly 50% of its usual electricity price to such a user.

For the cogenerators, this new capital equipment is estimated to cost \$350/kW at 1978 prices, or \$499.42/kW at 1985 prices. The cost of usual boiler equipment is so much lower that no salvage value was assumed. These capital costs are to be repaid at an 18% annual nominal rate (after taxes). Comparing these annualized capital costs to the proceeds from repurchased electricity, the manufacturing sector experiences a 1985 saving of \$5.30 million (1985) dollars, while the commercial sector saves \$10.6 million (1985) dollars. However, these "savings" do not take into account the cost of the increase in oil use, nor the reduction in on-site electricity purchases. This "saving" merely indicates that capital costs can be covered by the proceeds from utility repurchase of electricity.

Industrial Use of Coal - "COAL"

Before the imposition of higher standards for air quality, the industrial sector in New England burned coal as a major form of fossil fuel energy. This scenario examines the return to coal consumption levels of the mid-1960's.

New England Manufacturing Sector Fossil Fuel Use
(in 10^{12} BTU's)

	<u>Distillate</u>	<u>Natural Gas</u>	<u>Residual</u>	<u>Kerosene</u>	<u>Coal</u>	<u>Coal as % of Total</u>
1960	11.8	23.0	150.0	10.0	65.8	25.2
1962	10.8	25.3	161.0	9.4	57.9	21.9
1964	10.3	32.9	186.1	6.9	33.8	12.5
1966	15.9	42.8	149.0	5.9	24.3	10.2
1967	13.5	40.6	154.0	5.7	29.1	12.0
1974	14.3	50.0	142.8	3.4	6.6	3.0

This conversion to coal is not cost-free; substantial nuisance³ and scrubbing costs may be involved. The nominal price of a short ton of coal in 1985 provided to the manufacturer was raised to \$81.69 in order to reflect these higher costs (the base case price was \$65.00 and the high price was \$83.98). It is assumed that the greater use of coal means returning to burning 30 trillion Btu's in the year 1985. Whatever increase in coal use this means over the "BASE" projections, those Btu's will be removed proportionately from natural gas and residual use in the manufacturing sector.

Solar Heating - "SOLAR" (Appendix A-12)

Data for this simulation were provided by the Solar Action Office of the Commonwealth of Massachusetts. Passive solar systems are to be incorporated to reduce space-heating demands for the commercial services and residential sectors. These passive solar systems are to be designed into new construction and are assumed to have little cost. Hot water heating, on the other hand, has an associated capital cost of \$2500 (1978 dollars) for a system that reduces annual energy demand by 11 million Btu's. These capital costs are repaid at an 8% annual nominal rate in the residential sector and at a 10% annual nominal rate in the commercial sector.

Reductions in energy demand for hot water heating are assumed to be savings in electricity use. Reductions in demand for space heating are

shared in proportion to BASE CASE use of electricity, distillate, and residual (see Appendix A-12).

III. Energy Scenario Simulation Results

Fifteen simulations of the New England economy and its energy requirements for 1980 and 1985 which are grouped in four categories have been prepared and are discussed below. The four categories include preparation of a base projection, alternative economic growth projections, alternative energy price projections, and alternative technological assumptions. The following discussions will consider changes in energy requirements and costs in the alternative scenarios, followed by the consequences of those changes for economic activity and prices under our assumption of fixed nominal aggregate demand.⁴ The discussions will also highlight the important assumptions for each scenario as well as the behavior mechanisms which bring about the observed changes. As mentioned earlier, tables in Appendix B describe more completely the scenarios which have been simulated, and the complete computer outputs for each simulation have been provided to the Massachusetts Energy Office.

Preparation of a Base Projection

In preparing a base energy demand and economic projection, six simulations are examined. They include a simple extrapolation of 1974 energy-use patterns to 1980 and 1985 economic activity levels as projected by independent forecasters (EXTRAP). Potential energy conservation levels, which are believed to be both technologically feasible and economically efficient, are then examined (CON20, CON30, CON30NS). With these projections in mind, and using DOE's energy price projections, a base projection (BASE), which utilizes the Abbott-Lutostanski energy demand behavioral parameters,

is then presented. To examine the consequences of alternative assumptions on energy demand behavior, a simulation utilizing the DOE/PIES model parameters (FEABS) is then presented. Discussions of these individual simulations follow.

EXTRAP

For the EXTRAP simulations of 1980 and 1985, a basic economic growth path used to project aggregate demand levels is assumed. It is also assumed that energy demand per unit of production for each of our economic sectors is the same as in 1974. This simulation, therefore, assumes no conservation beyond 1974 and no price-induced behavioral responses are operational. This simulation projects energy needs for New England at 2.892 quadrillion Btu's in 1980 and 3.245 quadrillion Btu's in 1985. This represents a 2.03% per year growth in energy demand from 1974 to 1980, and a 2.30% growth rate from 1980 to 1985. This growth is led by an increase in demand for electricity of 2.7% per year to 1980 and 2.8% per year from 1980 to 1985, followed by an increase in demand for gasoline of 2.08% per year to 1980 and 2.33% per year from 1980 to 1985. Comparable growth rates for natural gas, distillate petroleum and residual petroleum are 1.0%, 1.83% and 1.71% to 1980, respectively, and 1.9%, 1.91% and 0.87% to 1985, respectively.

The differences in growth rates are due to the assumptions that real economic growth is 3.5% per year to 1980, and 3.5% per year from 1980 to 1985, plus shifts in the pattern of demand for products and services in the region due to increased per capita income and shifted sectoral prices, as a result of higher energy costs. Growth in output of the service (commercial) sector is 3.0% per year to 1980 and 3.0% per year to 1985, with comparable growth in manufacturing production of 2.3% to 1980 and 2.35% to 1985. Also,

the pattern of demand for energy by electric utilities has changed dramatically, due to an increase in nuclear production of 47% in 1980 and 88% in 1985 over the 1974 level of 57.7 billion Btu's. In addition, demand for transportation (both residential and commercial) increased 2.15% per year from 1974 to 1980 and 2.30% per year from 1980 to 1985, while demand for energy services by residential users increased by 1.0% per year to 1980 and 1.1% per year from 1980 to 1985.

These changes in energy demands resulted in increases in energy costs of 5.1%, 3.8% and 3.7% per year to the manufacturing, services, and residential sectors, respectively, to 1980 and 4.21%, 3.66% and 3.4% to 1985. These correspond to energy costs (in 1974 dollars) of \$1.423 billion to the manufacturing sector, \$2.402 billion to the service sector, \$1.046 billion for commercial transportation, \$2.289 billion for residential transportation, and \$2.712 billion for other residential energy uses in 1980. Comparable costs for 1985 are \$1.661 billion for manufacturing, \$2.857 billion for services, \$1.278 billion for commercial transportation, \$2.817 billion for residential transportation, and \$3.027 billion for residential energy services. These higher costs raise real sector prices above the 1974 levels by 6.3% to manufacturing, 3.8% for services, 10.1% for commercial transportation, 31.9% for residential transportation, and 3.3% for residential energy services for 1980. In 1985, those increases amount to 11.5%, 7.2%, 16.0%, 44.5%, and 8.9%, respectively. An overall price index for the New England economy increases 5.4% in 1980 and 9.8% in 1985 over 1974 prices. These increases are entirely due to higher real energy prices and they also account for average growth in output less than the 3.5% increase in real aggregate demand.

The resulting production increases mentioned earlier, plus our

assumptions on labor and capital market conditions, lead to a projection that total capital income increases 2.77% per year to 1980 and 2.83% per year from 1980 to 1985, while total labor income increases 4.10% per year to 1980 and 4.17% per year to 1985. The projected unemployment rates for the EXTRAP simulation are 6.358% in 1980 and 5.807% in 1985.

CON20

The CON20 scenario assumes that technologically feasible and economic conservation measures will be adopted throughout the New England economy. These conservation levels are exogenously imposed on 1974 energy-use patterns (the assumption in EXTRAP). There is no assurance that these conservation measures will be brought about. In addition, capital costs are increased to account for the costs associated with adopting these conservation measures. The resulting simulation presents a quite optimistic projection of New England's energy requirements and economic outcomes.

The direct effect of these conservation assumptions is to reduce energy requirements per unit of production. That effect will reduce both energy demands and energy costs below the EXTRAP projections. Total energy demand for CON20 is 10.3% less than for EXTRAP in 1980 and 19.1% less in 1985. Electricity demand falls 8.4% in 1980 and 17.1% in 1985, and petroleum use falls 11.0% in 1980 and 20.9% in 1985 from the EXTRAP projection. Total energy costs fall 6.25% for the manufacturing sector, 8.36% for the service sector, and 10.4% for residential users in 1980, and 13.1%, 17.1%, and 18.5%, respectively in 1985. These appear to be somewhat less than the conservation levels imposed. Since the lower electricity demand requires that fixed costs be written off over the lower demand levels, electricity prices are 1.9% higher in 1980 and 3.7% higher in 1985 than for EXTRAP. Furthermore, these

lower energy costs are passed on to sector prices, bringing about substantial reductions in those indexes and expansion of real output. In 1980, manufacturing prices are 0.4% below those in EXTRAP, while service prices fall 0.4%, and an overall price index is 1.1% lower. Comparable reductions for 1985 are 0.8%, 0.7%, and 2.2%, respectively. These reductions have been tempered somewhat by the increases in capital costs for those sectors. Also the total price reduction is much greater than the reductions for either services or manufacturing prices, because very substantial price reductions occur for residential uses and commercial transportation. These amount to 5.2% for commercial transportation, 34.9% for residential transportation, and 20.2% for residential energy services in 1985.

The lower prices also bring about increased production levels over the EXTRAP simulation. Overall output increases 1.0% in 1980 and 1.75% in 1985, reducing unemployment to 5.702% in 1980 (.656% lower than EXTRAP) and 4.673% in 1985 (1.134% lower than EXTRAP). This means approximately 40,000 jobs in 1980 and 75,000 jobs in 1985. Labor and capital incomes also increase 1.1% in 1980 and 1.9% in 1985.

After comparing CON20 and EXTRAP results, one is left with the overall impression that such conservation at the assumed costs would be of very substantial benefit to the economy. Later simulations (BASE and FEABS) will examine the extent to which price signals will encourage this conservation.

CON30

The CON30 simulations assume that even more expensive and extensive conservation levels are adopted by the manufacturing, services and residential

energy services sectors. These measures are still believed to be technologically feasible and economically efficient, though once again they are imposed exogenously with no assurance that they will be brought about.

As would be expected, energy demands for these three sectors in the CON30 simulations are below both the CON20 and EXTRAP projections, as are energy demands for the region overall. Total energy demand is 13.5% below the EXTRAP projection and 3.66% below the CON20 projection in 1980, and 25.8% and 8.3%, respectively, in 1985. Electricity demand is 12.3% below the EXTRAP level in 1980 and 25.0% lower in 1985, while petroleum demand is 14.2% lower in 1980 and 27.8% lower in 1985. Energy costs are below EXTRAP levels by 7.4% in 1980 and 15.1% in 1985 for manufacturing; 12.9% in 1980 and 26.6% in 1985 for services; 11.2% in 1980 and 14.9% in 1985 for commercial transportation; 12.8% in 1980 and 20.3% in 1985 for residential transportation; and 12.6% in 1980 and 26.0% in 1985 for residential services.

Since reductions in energy costs are greater than increases in capital costs (to adopt the conservation), sector prices are even lower in CON30 than in CON20. The overall price index for the CON30 simulation is 1.3% lower than the comparable EXTRAP index in 1980, and 2.6% lower in 1985. These are 0.2% lower than the comparable CON20 index in 1980 and 0.5% lower in 1985. Hence, it is clear that these assumptions suggest that the CON30 conservation levels are economically efficient actions at assumed cost levels.

Again, lower prices increase production and incomes at fixed dollar spending levels. Overall production is 1.17% higher in 1980 and 2.18% higher in 1985 than for EXTRAP. These increases will also increase

incomes and reduce unemployment. For this simulation case, unemployment rates are 5.583% in 1980 and 4.438% in 1985, which are 0.775% and 1.369% lower than EXTRAP rates in 1980 and 1985, respectively.

CON30NS

One problem with the CON30 results is that much residual-fired electric generation capacity is idled. In 1974, New England burned 0.451 quadrillion Btu's to generate electricity, while in CON30, for 1985 only 0.220 quadrillion Btu's are burned, with only a slightly reduced capacity expected. One alternative assumption might be that the Seabrook nuclear power plant would not be in operation in 1985, and that the fixed costs associated with the Seabrook plant are not included in the rate base. Since this would reduce electric rates in 1985, it would make CON30 results even more optimistic. In order to assess this effect, an additional 1985 simulation was run and that run was labeled CON30NS.

The initial effect of the CON30NS assumptions is that electricity prices are lower by 3.56% than for the CON30 simulation of 1985. That is because fixed costs to produce electricity are lower, so the rate base is lower. In turn, energy costs by sector are lower than in CON30. For the manufacturing sector, energy costs are 1.9% lower, even with a slight increase in production and energy use. For the service sector, energy costs are 1.2% lower, even though energy use is up 0.11%, due to a production increase of .11%. These cost reductions have a net effect of reducing the overall price index by 0.1%, a reduction similar to what is observed for the separate economic sectors. The savings to the residential sector for this simulation amounts to \$32 million, or 1.4% of their energy costs other than for transportation.

This simulation is otherwise little different from CON30, as the change in assumptions is quite slight. Both CON30 and CON30NS suggest that if the higher conservation levels are achievable at assumed costs, even more savings to the economy than was suggested by the CON20 simulation is possible. The policy question which still remains is how these conservation levels can be brought about.

BASE

The BASE simulation scenarios represent our basic projections of energy prices, economic growth, behavioral responses, and energy demands. BASE differs from EXTRAP in that behavioral mechanisms have been added which allow energy uses per production unit to vary in response to changing real energy prices. The parameters and assumptions used to capture these behaviors are those estimated in the Task III report of this project. Hence, this simulation case will allow both price-induced energy substitution and energy conservation. It was our initial expectation that this simulation should be somewhat similar to CON20, since relatively large real energy price increases over 1974 levels are assumed. That expectation was not realized, however, as conservation levels were not as substantial as assumed in CON20.

The BASE projections indicate that total energy demand for the New England economy will be 2.730 quadrillion Btu's in 1980 and 2.950 quadrillion Btu's in 1985. These demand levels are 94.4% and 90.9% of the EXTRAP levels, respectively, and 105.2% and 112.3% of the CON20 levels. Hence, an intermediate level of conservation is achieved for the assumed price and behavioral

responses. These energy demands correspond to a 1.07% per year growth in energy demand to 1980 and 1.55% per year from 1980 to 1985. For the separate fuels, somewhat different results are obtained. BASE projections for 1985 are 102.5% of EXTRAP projections for electricity demand, or 314.3 billion Btu's; 102.9% for natural gas demand or 317.2 billion Btu's; 79.9% for gasoline demand or 675.5 billion Btu's; 93.7% for distillate demand or 804.4 billion Btu's; and 93.4% for residual demand or 836.5 billion Btu's. Hence, intermediate results are obtained only for distillate and residual petroleum use. Electricity demand and natural gas demand actually increase over EXTRAP results, as the price paths assumed move economic sectors into greater use of these fuels per unit of production. Annual growth rates from 1974 to 1980 corresponding to the BASE energy demand levels are 3.13% per year for electricity; 0.93% per year for natural gas; -0.3% per year for gasoline; 1.17% per year for distillate; and 1.20% per year for residual. Annual growth rates from 1980 to 1985 are 2.74% per year for electricity; 1.87% per year for natural gas; 0% per year for gasoline; 0.78% per year for distillate; and 0.61% per year for residual.

On the other hand, for each of the economic sectors, energy costs are between the EXTRAP and CON20 projections, but closer to EXTRAP. The following summarizes the energy cost projections.

<u>Sector</u>	<u>Energy Cost (\$ millions)</u>		<u>% of EXTRAP Costs</u>	
	<u>1980</u>	<u>1985</u>	<u>1980</u>	<u>1985</u>
Manufacturing	1333	1473	93.7	88.7
Commercial Transportation	924	1078	88.3	84.4
Services	2356	2781	98.1	97.3
Residential Transportation	1974	2211	86.2	78.5
Residential Energy Services	2692	2955	99.3	97.6

The largest savings are obtained through conservation in transportation, with some conservation apparent in the manufacturing sectors. For services and residential energy services, it appears that energy substitution largely dominates, though some conservation is achieved, amounting to about 3% of costs in 1985.

It should also be observed that the greater electricity demand in BASE yields lower electricity prices (by 0.4% in 1985) than for EXTRAP, accounting for some of the cost reductions.

The intermediate energy cost projections, in turn, account for real sector price increases, due to the higher energy prices, which are less than those projected in EXTRAP but greater than the CON20 projections. Manufacturing prices in BASE increase 5.9% over 1974 prices in 1980, and 10.9% in 1985. Services prices increase 3.7% in 1980 and 7.1% in 1985, while residential energy services cost 1.7% more in 1980 and 4.9% more in 1985. The overall price index increases 4.7% in 1980 or 0.7% less than in EXTRAP but 1.2% higher than in CON20, while that index in 1985 is 8.6% or 1.2% less than in EXTRAP but 2.1% greater than for CON20. Hence, production and income levels, as well as unemployment projections, will be between EXTRAP and CON20 projections, though closer to the former. The projected unemployment rates are 5.913% in 1980 and 5.108% in 1985.

The BASE projection, with its behavioral adjustments in energy demand included, suggests that expected price increases will not bring about all desirable energy conservation, and this will impose some cost on the economy. For more detail on the BASE projection, one should consult Table B-6 in Appendix B.

FEABS

Since earlier versions of the NEME model utilized the same parameters as the DOE/PIES model, the consequences of making such assumptions are of some interest. A comparison of simulations with those parameters and the parameters in BASE will indicate the nature of the differences in those parameters. The FEABS simulation uses the DOE/PIES parameters, and so facilitates such comparisons. It should be noted that the transportation models assumed are virtually identical, so that significant differences in energy-use patterns will be obtained only for the manufacturing, service and residential energy service sectors.

The first observation to be made is that the FEABS projections are somewhat more pessimistic than BASE projections. Less energy conservation and more energy substitution results when the PIES parameters are assumed. Total energy demand for FEABS is 3.99% higher than for BASE in 1980 and 6.54% higher in 1985. Demand for electricity in 1980 is 5.38% higher in FEABS than in BASE, and in 1985 it is 6.33% higher. Petroleum demand is also 4.09% higher in 1980 and 6.88% higher in 1985.

In addition, the greater energy demands per unit production at the same prices as BASE yield estimates of greater energy costs in the three affected sectors. Manufacturing energy costs are 8.78% higher in 1980 and 21.3% higher in 1985. Services energy costs are 6.49% higher in 1980 and 6.65% higher in 1985. Residential energy costs are 0.45% higher in 1980 and 3.01% higher in 1985. This amounts to an additional energy cost to the New England economy of \$515 million (in 1974 dollars) in 1985 if the more pessimistic behavioral assumptions prevail. When these costs are

compared to costs in the EXTRAP simulation, it is seen that DOE/PIES parameters imply greater energy costs than if firms and residences continued with the 1974 energy-use patterns. This last point is strong evidence that the DOE/PIES parameters are unreasonable descriptions of energy use behavior.

The overall regional and sectoral price indexes are lower for FEABS than for EXTRAP only because higher transportation costs to all sectors are assumed in EXTRAP simulations. Since these results are clearly unacceptable, the Abbott-Lutostanski model of energy demand behavior will be used throughout in our basic projections of New England energy demands.

Alternative Economic Growth Projections

Two alternative assumptions on the likely economic future of the New England region have also been considered. The simulation scenario named HIGRO assumes that real growth in gross regional product will be 3.95% per year to 1980 and 3.35% per year from 1980 to 1985, in place of the assumptions used in both EXTRAP and BASE that GRP will increase at 3.5% per year from 1974 to 1985. The LOGRO scenario assumes that growth in real GRP is 3.33% per year to 1980 and 2.97% per year from 1980 to 1985. The results obtained are discussed below.

HIGRO

The HIGRO simulation replaces assumptions on real GRP growth, labor productivity, wages, and net export demand with more optimistic estimates. It assumes very rapid economic growth to 1980, and though the annual growth rate from 1980 to 1985 is lower, a higher real GRP is achieved in 1985, due to the higher starting point in 1980. Since energy price projections are unchanged for this case, so are energy-use patterns per unit of production. The first round effect in this simulation, then, is to increase demand for

sector products and services, and, in turn, increase output. Changes which occur in total energy use are due to the new projected output pattern, which grows at different rates for the different sectors.

In 1980, HIGRO production is 2.86% greater than the BASE production projection, while manufacturing production is 2.57% greater and services production is 3.44% greater. In 1985, HIGRO production is 1.59% greater than BASE, with manufacturing production 1.39% greater and services 1.88% greater. These production increases lead to energy cost increases of 2.40% in 1980 and 1.36% in 1985 for the manufacturing sector and 3.27% in 1980 and 1.80% in 1985 for services. These are clearly driven by the output change, with a slight reduction in the electricity price both reducing costs somewhat and slightly shifting energy-use patterns.

Similar but much smaller effects are observed for the residential sector. That is, since income elasticities of demand for energy services are relatively small, there is little change in either residential transportation or residential energy services usage. Energy costs for these two sectors rise only 0.23% and 0.14%, respectively. These slight changes for two sectors using almost 40% of the region's energy mean that total energy use increases are much smaller than income increases. For example, in 1985, the HIGRO total energy use projections is only 0.99% higher than BASE, with electricity use up 1.17% and petroleum use up 1.20%. These are a result of an income level which is 1.99% higher in 1985.

The price increases which are observed occur because of slightly higher wage costs. One should note that prices for residential energy services and residential transportation are identical in BASE and HIGRO. Hence, driving the economy faster increases energy use at about half the

rate of economic growth, with little or no effect on prices from energy costs.

LOGRO

A simulation assuming more pessimistic economic projections was also performed in order to determine if the observed effects are symmetric with income increase effects. In the LOGRO simulation, real economic growth was assumed to be 3.45% per year to 1980, yielding a GRP 0.29% lower than in BASE; and 2.83% per year from 1980 to 1985, yielding a GRP in 1985 which was 3.57% lower than BASE. Other changes were similar to but in an opposite direction from BASE than HIGRO. Again, energy prices were fixed at BASE levels, and so the same mechanisms operating in HIGRO were working in the LOGRO simulation. Since income changes in 1980 were of such a small magnitude, the 1985 solution only will be compared to BASE and HIGRO.

In 1985, LOGRO production is 2.90% lower than BASE, with manufacturing production 2.65% lower and services production 3.50% lower. This is quite close to the magnitude of effect observed in HIGRO. For residential energy services, demand is 0.32% below base, while residential transportation demand is 0.59% below base, again indicating relatively small income elasticities for these sectors. Energy costs fall 2.58% for manufacturing, 3.34% for services, 0.59% for residential transportation, and 0.68% for residential energy services. In this case, the smaller electricity demand has slightly raised electricity prices, since fixed costs must be written off over a smaller output. The behavior responses induced by this price change account for the difference between production and energy cost changes.

With a 3.57% income (GRP) decrease in 1985, total energy usage falls 1.00% below the BASE projection, with electricity demand falling 2.61% and petroleum demand falling 2.46%. Hence, it does appear that income changes have symmetric effects on energy use. Also, these energy-use changes have little effect on prices, as the observed changes are largely due to changes in wage costs.

Alternative Price Projection

Among the weakest assumptions used in our projections are the energy price estimates. Furthermore, these prices may be offered through public policy initiatives. Hence, simulations assuming different energy price projections are of considerable interest. Four such simulations will be presented here: one assumes higher energy prices (HIPRI), another lower energy prices (LOPRI), the third assumes a "crisis scenario", where the lower prices prevail in 1980, but the higher prices occur in 1985 (HIPLOP), and the fourth examines the high-price scenario, using the DOE/PIES behavioral assumptions (FEAHP). Discussion of these four simulations follows.

HIPRI

The high-price scenario assumes all energy prices are somewhat higher than the prices used in the BASE projection. The actual price assumptions have been presented earlier. The direct consequences of these higher prices are to both raise costs to economic sectors and to induce changes in energy-use patterns in response to these higher prices. It is assumed that the Abbott-Lutostanski model is the correct description of energy demand behavior for this scenario.

The most substantial changes in energy-use patterns are for

natural gas and residual use by the service sector, where decreases in use per unit of production (from BASE levels) of 15.8% and 6.96% occur in 1985; manufacturing use of distillate, where a 50% decrease occurs in 1985; and electricity and distillate use by the residential sectors, where decreases of 3.08% and 2.94% occur by 1985. These changes comprise both energy conservation and energy substitution by these sectors, as some increases in per unit use are observed. These changes, in turn, cause energy cost increases to sectors of a magnitude somewhat less than the price increases. The results are that energy costs increase 1.65% in 1980 and 8.62% in 1985 to the manufacturing sector; 0.76% in 1980 and 4.26% in 1985 in the commercial transportation sector; 2.33% in 1980 and 13.4% in 1985 for the service sector; 0.86% in 1980 and 4.61% in 1985 for residential transportation; and 1.45% in 1980 and 11.1% in 1985 for residential energy services.

These shifts in energy-use patterns and higher costs yield energy usage in the HIPRI simulations as well as a shift in the overall energy demand pattern. The following table summarizes the changes in total energy usage induced by the higher energy prices:

<u>Energy Form</u>	<u>Demand (10¹² Btu's)</u>		<u>% of BASE Demand</u>	
	<u>1980</u>	<u>1985</u>	<u>1980</u>	<u>1985</u>
Total Energy	2697.0	2766.0	98.8	93.8
Electricity	271.0	292.6	98.9	93.1
Natural Gas	286.3	302.8	99.1	95.5
Gasoline	645.8	639.7	99.1	94.7
Distillate	744.2	764.8	99.2	95.1
Residual	818.7	752.7	98.5	90.9
Coal	80.7	143.5	98.9	95.5

The foregoing table clearly demonstrates that these higher energy prices will bring about some conservation, but that conservation is still not as great as was found for the CON20 solutions. Also, this conservation comes at a substantial cost to the economy. The higher energy prices are passed on as higher product and service prices, with an overall price increase of 1.2% over BASE prices in 1985. These price increases are led by price increases to the residential sector of 7.0% for transportation and 13.1% for energy services in 1985. This means an additional energy cost to households of \$429 million in 1974 dollars.

The higher sector prices also lead to lower output at fixed demand levels. Overall production falls 0.20% in 1980 and 1.02% in 1985. Labor income is 1.03% below the BASE projection for 1985, and capital income is 0.84% below the 1985 BASE projection. Unemployment increases 0.123% in 1980 and 0.717% in 1985, or there are 7,500 fewer jobs in 1980, and 47,440 fewer jobs in 1985 than in BASE. This substantial cost should not be surprising, however, as virtually all primary energy inputs to New England are imported; any economic benefits of higher prices leave the region. If these higher prices are the result of federal policies to induce conservation and reduce dependence on foreign oil, the economic costs must be weighed against the benefit of the energy conservation achieved. But ways of bringing about that conservation which avoid the use of potentially damaging higher prices, or which use taxes whose proceeds remain in the region, are clearly superior to these results.

FEAHP

The higher energy price scenario was repeated using the DOE/PIES behavioral assumptions, and that simulation is FEAHP. As was pointed out

in our Task III report, and earlier in this report, these assumptions yield greater energy substitution and less energy conservation than the Abbott-Lutostanski model. Hence, this simulation will be even more pessimistic than was HIPRI. More energy use and higher energy costs are the result of this simulation.

The following table compares energy usage in FEAHP, HIPRI, and FEABS in 1985.

Energy Form	$\frac{\text{FEAHP Demand}}{\text{FEABS Demand}}$	$\frac{\text{FEAHP Demand}}{\text{HIPRI Demand}}$
Total Energy	0.955	1.086
Electricity	0.960	1.096
Natural Gas	0.937	1.006
Gasoline	0.949	1.012
Distillate	0.970	1.047
Residual	0.944	1.215

A comparison of the conservation implied here and by the HIPRI solution suggests that higher prices assumed for 1985 yield about 2% more energy conservation using the Abbott-Lutostanski assumptions.

A comparison of energy costs yields similarly pessimistic results. In 1985, energy costs are 21.8% higher than HIPRI for the manufacturing sector; 6.1% higher than HIPRI for the service sector; and 3.45% higher for residential energy use. Prices increase in FEAHP by 1.4% over FEABS and 0.4% over HIPRI. Hence, the overall consequences of higher prices with the DOE/PIES parameter assumptions are similar in direction and nature to the effects discussed in HIPRI, but more pessimistic in magnitude, due to the lesser extent of energy conservation implied. This is verified by the similar but larger increases in unemployment and reductions in output and incomes.

Hence, the FEAHP simulation has also indicated that substantial economic costs come with higher energy prices, but that some energy conservation is achievable. The cost to induce the same conservation is much higher under these assumptions than under the HIPRI assumptions, however.

LOPRI

Also of interest are the consequences of lower energy prices to the New England region. The simulation which models that possibility is LOPRI. Mechanisms operating in this simulation are the same as in HIPRI, but they are working in opposite directions. Hence, the lower energy prices assumed lead directly to greater energy use per unit of production, plus some energy substitution. Again, the greater changes in energy use per unit of production are for distillate use by the manufacturing sector, natural gas and residual use by services, and electricity, gasoline, and distillate use by the residential sector. These increased uses reduce to some extent the cost savings from lower prices.

Nevertheless, lower prices do mean somewhat lower energy costs to the region. Manufacturing costs are 0.3% lower than BASE in 1980 and 0.54% lower in 1985. Services costs are 0.9% lower in 1980 and 4.78% lower in 1985, while residential excess costs are 1.0% lower in 1980 and 5.21% lower in 1985. These, in turn, are passed on as cost reductions in sector prices, particularly for residential energy use. Manufacturing prices are lower in 1985; services prices are 0.3% lower in 1985; residential energy services prices are 0.8% lower in 1980 and 3.8% lower in 1985, while overall prices fall 0.9% in 1980 and 0.6% in 1985.

These somewhat lower sector prices raise production slightly, increasing incomes proportionately and reducing unemployment. Overall production is 0.06% higher in 1980 and 0.51% higher in 1985, resulting in decreases in unemployment of .075% in 1980 and 0.34% in 1985. These somewhat smaller effects than those observed for HIPRI are due to the fact that the change in prices from BASE is less for LOPRI than for HIPRI. Nevertheless, this simulation does support the notion that lower energy prices will benefit the region, since they simply reduce import costs. Differences are also explained by the fact that fixed costs for nuclear plants are increased in HIPRI, but not lowered in LOPRI, resulting in a greater shift in the electricity price in HIPRI.

HIPLOP

The final alternative price projections considered were intended to model the possibility of a crisis situation occurring in the mid-1980's. That is, it is assumed that low prices prevail to 1980, but high prices are the outcome in 1985. Hence, any preparations by the economy in the HIPRI solution, due to higher prices in 1980, do not occur in this simulation. The presumption then is that the economy is less prepared for high prices in 1985 than in the HIPRI simulation, and so a comparison of those simulations is of interest; 1980 outcomes for this simulation are identical to LOPRI results. The results obtained for HIPLOP, given the assumptions made here, actually suggest only a slight cost due to lack of preparation for 1985's higher energy prices.

The only substantial difference in energy usage is distillate use by the manufacturing sector, which is 8.9% higher in HIPLOP than in HIPRI. Other changes in use are less than 1%. This means changes in energy costs

to sectors are also small. The following Table summarizes that effect:

<u>Sector</u>	<u>Energy Cost Increase (\$ 1974 millions)</u>	<u>% Increase over HIPRI</u>
Manufacturing	12.0	0.75
Commercial Transportation	1.0	0.09
Services	1.0	0.03
Residential Transportation	0.0	0.00
Residential Energy Services	18.0	0.55

These small cost changes, in turn, only change sector prices, production and unemployment slightly from the HIPRI solution. Only the change in unemployment is large enough to be estimated, and that is only 0.012% or 800 jobs. Certainly the benefits to lower prices in 1980 are much greater than the costs of this lack of preparation in 1985. One note of caution should be raised. This simulation assumes the crisis occurs at least two years before 1985, so that the lags in behavioral adjustment are small. The very short-run effects of such a crisis will obviously be greater than these suggest, but the costs of preparing for a crisis which may or may not occur must be carefully weighed against the benefits of lower import costs.

Technological Alternatives

Recent events in energy markets have also brought attention to new technological alternatives which could enhance energy conservation in New England, or reduce dependence on petroleum as an energy source. Three such alternatives are cogeneration of electricity by the manufacturing and service sectors, modeled in the simulation labeled COGEN; additional use of coal by the manufacturing sector, called COAL; and use of solar energy for space and water heating by both residential users

and the service sector, called SOLAR. For each of these cases, energy uses have been altered to reflect the potential utilization of these options, with other energy uses per unit frozen at projected BASE levels. Simulation results will be utilized to examine the potential energy demand and economic effects of adoption of these technologies. Since it is unlikely that any of these alternatives will be adopted by 1980, only simulation results for 1985 have been produced, and these are discussed below.

COGEN

The COGEN simulation assumes that manufacturing and service sector firms generate some of their own electricity and use the generated waste heat. This reduces electricity usage and increases petroleum usage, with the use of waste heat more efficiently utilizing the energy used to generate electricity.

The primary effect of this technology is to increase fossil fuel usage by the service and manufacturing sectors while reducing fossil fuel usage by the electric utilities to a greater extent. The following table summarizes the net changes in the energy demand pattern for New England as a result of the utilization of cogeneration technologies:

<u>Energy Form</u>	<u>Decrease in Demand over BASE (trillion Btu's)</u>	<u>% Decrease Over BASE</u>
Electricity	- 0.2	-0.06
Natural Gas	0.2	0.06
Distillate	-14.3	-1.75
Residual	2.5	0.30
Coal	67.2	44.7
TOTAL ENERGY	58.0	1.97

As the above table demonstrates, and due largely to our assumption that reduced capacity in the electric sector will come from two plants presently

slated to be converted to coal production, the saving in energy generated by this simulation is only in coal demand. In fact, petroleum demand increases in this simulation. It is also interesting to observe that usage of petroleum by electric utilities drops 10.9%, indicating that such a fraction of petroleum-generating capacity in electric utilities is idled, along with the two coal-fired plants.

The economics of cogeneration, as assumed here, are such that no reduction or increase in sector prices is apparent. The energy cost savings to the manufacturing and service sectors of \$163 million and \$18 million are just offset by increased costs to install and operate cogeneration equipment. Hence, no change in production, unemployment, or incomes is caused by adoption of this technology to the extent and at the costs assumed here. These marginal economic effects are to be expected, as the intent of the technology is to save energy, but it is interesting to note that the savings generated are more likely to be for coal than for petroleum.

COAL

The COAL simulation assumes manufacturing firms in New England return to their greater coal use of the mid-1960's. Hence, coal use by the manufacturing sector increases from 8.6 trillion Btu's in BASE to 30.0 trillion Btu's in COAL, while natural gas use falls by 6.4 trillion Btu's and petroleum use falls by 15.1 trillion Btu's. Since the economics of this change under our assumptions turn out to be marginal, and no apparent effect on sector prices is felt, then energy uses by all other sectors is also unchanged. Hence, the changes in energy use for the manufacturing sector are also the changes in energy use for the New England economy. The cost savings to the manufacturing sector of \$4 million are just offset

by the additional costs which must be borne to burn coal instead of natural gas and petroleum.

The conclusion to be drawn from this simulation, then, is simply that if firms can be encouraged to return to earlier coal utilization rates, petroleum dependence can be reduced with little apparent effect on the economy. Convincing manufacturing firms to adopt these changes, when they appear to reject the profitable conservation measures as well, is another matter.

SOLAR

The SOLAR simulation assumes that solar energy replaces fossil fuel usage and electricity demand for the service and residential sectors to provide space and water heating. The 12.2 trillion Btu's of solar energy used by the service sector replace 3.0 trillion Btu's of electricity, 5 trillion Btu's of distillate and 4 trillion Btu's of residual. This results in an energy cost saving of \$34 million. In the residential sector, 12.4 trillion Btu's of solar energy replaces 4 trillion Btu's of electricity and 8.3 trillion Btu's of distillate, bringing about a cost saving of \$35 million.

On the other hand, reductions in electricity demand require fixed electricity costs to be charged over a smaller output, raising electricity prices by 0.41% over the BASE projection. Also, installation costs increase service sector costs, so that no perceptible change in sector prices is observed. Only the cost of residential energy services falls appreciably and that is in part due to the fact that no attempt was made to charge capital costs to the residential sector to pay for solar equipment. Hence, only extremely small changes in production, incomes, and unemployment are observed.

The major impact of this adoption, then, is to shift energy demands away from electricity, natural gas, petroleum, and coal. Also, total energy demand falls by 16 trillion Btu's, since the more efficient solar energy replaces electricity usage. The following table summarizes energy demands for the SOLAR simulation:

<u>Energy Form</u>	<u>SOLAR Demand</u> (trillion Btu's)	<u>% Decrease from Base</u>
Total Energy	2934.0	0.54
Electricity	397.2	2.26
Natural Gas	317.3	0
Gasoline	675.7	0
Distillate	790.7	1.70
Residual	811.6	2.98
Coal	148.6	1.07
Solar	24.6	----

Thus, the SOLAR simulation allows a reduction in energy demand for New England and, more importantly, less dependence on petroleum, with virtually no impact on the economy. Again, the question which remains is how this adoption of solar energy will be brought about.

IV. CONCLUSIONS

The preceding simulations of the New England economy and its likely energy use have provided a number of insights into the problems with and potential for energy policy in the region. In addition, they provide a strong basis for projecting New England's energy requirements in 1980 and 1985.

The basic projections suggest that energy demand in New England will increase at 1.55% annual growth rate from 1980 to 1985. Electricity demand will grow at a rate of 3.13% annually to 1980, and 2.74% annually from 1980 to 1985. On the other hand, petroleum demand will increase 1.2%

per year to 1980 and about 0.7% per year from 1980 to 1985. These growth rates reflect approximately 20% conservation in transportation, 10% conservation by the manufacturing sector, and 3% conservation for services and residential energy demand in 1985 over per unit energy uses in 1974. The higher energy prices assumed for these projections bring about the observed conservation; but they also cause total energy costs and, hence real sectoral prices, to rise 4.7% by 1980 and 8.6% by 1985.

Examination of alternative economic projections also suggested that alternative projections can lead to somewhat different energy demands. Our results indicate that for every one percent increase in projected Gross Regional Product, energy demand will increase by about 0.5%. Increases in petroleum and electricity demand are slightly greater than that figure. This result is largely due to the fact that income elasticities of demand for residential energy use are relatively low, so that the growth in residential transportation and residential energy services is less than that of overall economic growth.

We also found that the choice of a model specification of energy demand behavior can substantially alter projections. The behavioral parameters estimated in the Task III final report of this project yield considerably more optimistic projections than do the parameters of the DOE/PIES "two-step" model. In addition, the unexpectedly high energy costs resulting from the DOE/PIES parameters are additional evidence that our regional parameter estimates, and particularly our projections of exogenous electricity demand increases are a more reasonable approximation of New England behaviors.

The conservation simulations suggest that apparent technological opportunities exist to obtain substantially greater levels of energy conservation. They indicate that technologically feasible and economically efficient measures can reduce energy demand per capita to a level 18.3% below our basic projection by 1985. Petroleum demand could be reduced by about 15%, as well. Such conservation would also be of substantial benefit to the economy. Sectoral prices could be as much as 1.4% lower by 1985, with unemployment rates up to 0.67% lower. These come about as a result of the real cost savings due to energy conservation.

Unfortunately, higher energy prices which are within a reasonable upper limit are unlikely to elicit this conservation. The price scenarios examined, including one with quite high energy prices, yield energy savings of no more than 8.6%, in total, by 1985. This raises two questions which remain to be addressed. The first is, how can the technological opportunities which appear to exist be encouraged by policy? Price signals which reflect the real scarcity of energy are an important means of achieving an efficient allocation of this resource, but there appear to be latent opportunities for conservation which will not be fully exploited. Raising energy prices above the marginal cost of supply in order to further induce conservation imposes a high economic cost. Some other means of tapping this latent conservation potential should be investigated. The second question is, are the cost assumptions of these

technological opportunities realistic? Any time such apparently profitable conservation opportunities are rejected by economic actors, one should ask himself if some hidden costs might have been neglected in developing the conservation estimates. Our simulation results suggest, however, that pursuing these conservation opportunities may be the best opportunity for regional energy policy makers.

The alternative price scenarios also indicate that higher energy prices impose a substantial economic cost to the New England region. Since virtually all primary energy sources are imported, higher energy prices raise real costs to the region without imparting any increase in regional incomes. If higher energy prices are the result of federal policies to induce conservation and reduce dependence on foreign oil, these economic costs must be weighed against the benefit of energy conservation achieved. Ways of bringing about that conservation which avoid excessive price increases or which use taxes whose proceeds remain within the New England region are clearly superior. Those higher energy prices may also be intended to prepare the regional economy for an impending "crisis" of sudden and substantial price increases, but the economic benefit of such preparations which are price-induced are small in the medium- to long-run, especially when compared to the costs of higher energy prices. That is not to say that energy conservation as a preparation for such a crisis is undesirable, but rather that price signals alone are not a completely effective means of eliciting such preparation.

Technological options, including increased utilization of solar energy, increased coal usage by the manufacturing sector, and cogeneration

of electricity and useful "waste heat" were also explored. These options had little macroeconomic impact, but could bring about net energy savings. Additional solar use could reduce regional petroleum demand by 1.65%, and additional coal use could substitute coal for 0.9% of that demand. The cogeneration alternative, according to current assumptions, would reduce coal utilization by the region through reduced electricity demand, and would make conversion of two coal-fired electric generating plants unnecessary. A more reasonable alternative than our current assumptions for cogeneration might be the elimination of one planned nuclear power plant, rather than idling residual-fired capacity and foregoing coal conversion; but that is if cogeneration activities are implemented. A question which remains is how these relatively marginal economic ventures could be encouraged, so that the obtainable energy savings could be achieved.

The simulation results and our work in preparing input highlighted the importance of planning in the electric sector, as well. Both planning and bringing on-line sufficient capacity without providing excessive capacity, and controlling costs, are important issues. What happens in other sectors of the economy can significantly impact electricity prices and demand, so coordinated planning is desirable. This is probably another area in which regional energy policy makers should be involved.

The details of the individual simulations suggest a number of other interesting problems and issues. The most significant result

of this work, however, is that policies which depend on energy price manipulations are less likely to be productive than policies which affect energy conservation behavior directly. Also, the micro-economics of technological and energy conservation alternatives deserve further careful examination, as many questions are raised when one examines the consequences of our current assumptions.

FOOTNOTES

- ¹ Scenarios examining exogenously forced conservation assume conservation levels believed to be possible technologically, without concern for how adoption of the required conservation measures would occur. It is unlikely that such measures would be adopted without government encouragement or higher energy prices. The base projection case examines how much of such conservation is likely to occur, given assumptions about likely energy price increases and user responses.
- ² Formats for the tables generated by computer simulation of the NEME model are extensively described in the Task I final report of this project.
- ³ There are additional costs associated with coal utilization that are not incurred in the use of other fossil fuels. Examples are storage costs, costs of railway sidings, handling cost, and waste disposal.
- ⁴ The assumption of fixed nominal aggregate demand is typical of planning models, and is reasonable given the issues to be addressed here. It should be noted, however, that the effect of aggregate demand changes on import costs and demand for energy-related equipment is a debatable issue. Resolution of that issue is dependent upon the theoretical macroeconomic framework assumed and particularly changes in government fiscal and monetary policies in response to changes in observed unemployment and inflation outcomes. Our assumptions represent a neutral government response.

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VII. Appendix A

In this Appendix, simulation inputs are detailed. Twelve sub-Appendices are presented. Appendix A-1 documents energy prices and electric sector inputs, Appendix A-2 presents the economic projections, and Appendices A-3 through A-12 describe the separate simulation cases.

APPENDIX A-1: ENERGY PRICES & ELECTRIC SECTOR INPUTS

Table A-1-1. Energy Prices to the Manufacturing Sector, Inputs to Projections

Energy Form	Units	1974	Basic Projection		High Price		Low Prices	
			1980	1985 (in current dollars)	1980	1985	1980 (current dollars)	1985
Nuclear	(¢/kWh)	0.212	0.486	0.916	0.700	1.500	0.376	0.482
Natural Gas	(\$/mcf)	1.720	2.70	3.754	2.84	4.861	2.699	3.465
LPG	(\$/barrel)	9.068	16.39	22.53	16.92	26.81	16.126	20.702
Gasoline	(¢/gallon)	35.23	73.72	103.68	74.98	114.05	71.860	89.559
Kerosene	(¢/gallon)	34.961	57.32	79.95	59.996	84.74	56.760	72.063
Distillate	(¢/gallon)	32.50	53.382	72.04	54.77	83.06	52.439	66.613
Residual	(\$/barrel)	12.43	20.98	27.24	21.55	31.592	20.733	26.259
Coal	(\$/short ton)	25.15	48.39	65.00	50.79	83.98	47.396	60.844

		(in constant '74 dollars)		(constant '74 dollars)	
Nuclear	(¢/kWh)	0.212	0.336	0.484	0.260
Natural Gas	(\$/mcf)	1.72	1.868	1.965	1.868
LPG	(\$/barrel)	9.068	11.343	11.709	11.16
Gasoline	(¢/gallon)	35.23	51.017	51.889	49.73
Kerosene	(¢/gallon)	34.961	39.668	41.520	39.28
Distillate	(¢/gallon)	32.50	36.942	37.903	36.29
Residual	(\$/barrel)	12.43	14.519	14.913	14.348
Coal	(\$/short ton)	25.15	33.488	35.149	32.80

Appendix A-1 (cont'd)

Table A-1-3. Factors that Adjust Different Energy Prices to Different Users.

(Energy Price to Sector/Energy Price to Manufacturing)

Energy Form	Agr., Mining, Construction	Comm. Trans.	Historical 1974			Electric Utility
			Services	Res. Trans.	Resid.	
Electricity	1.0	1.0	1.397	1.0	1.4346	1.0
Nuclear	1.0	1.0	1.397	1.0	1.4346	1.0
Natural Gas	1.0	1.0	1.26	1.0	1.58	0.5814
LPG	1.0	1.0	1.0	1.0	1.0	1.0
Gasoline	1.0	1.166	1.0	1.166	1.0	1.0
Kerosene	1.0	1.0	1.0	1.0	1.0	1.0
Distillate	1.0	1.0311	1.0005	1.0	1.0953	0.9613
Residual	1.0	1.0	1.0999	1.0	1.0	0.9203
Coal	1.0	1.0	1.0	1.0	1.0	1.0
Exotic	1.0	1.0	1.0	1.0	1.0	1.0

(for 1980 and 1985 projections)						
Electricity	1.0	1.0	1.17	1.0	1.1778	1.0
Nuclear	1.0	1.0	1.0	1.0	1.0	1.0
Natural Gas	1.0	1.0	1.26	1.0	1.26	1.0
LPG	1.0	1.0	1.0	1.0	1.0	1.0
Gasoline	1.0	1.0619	1.0619	1.0619	1.0	1.0
Kerosene	1.0	1.0	1.0	1.0	1.0	1.0
Distillate	1.0	1.0	1.0	1.0	1.068	0.885
Residual	1.0	1.0	1.0	1.0	1.0	0.92
Coal	1.0	1.0	1.0	1.0	1.0	0.873
Exotic	1.0	1.0	1.0	1.0	1.0	1.0

Appendix A-1 (cont'd)

Table A-1-2. Normalized Energy Prices to Manufacturing (1974)

<u>Energy Form</u>	<u>\$/million Btu's</u>	<u>Heat Content Conversion Factors</u>
Nuclear	0.6213	3412 Btu's per kWh
Natural Gas	1.7000	1011 Btu's per cubic foot
LPG	2.2619	4.009 million Btu's per barrel*
Gasoline	2.8195	5.248 million Btu's per barrel*
Kerosene	2.5897	5.670 million Btu's per barrel*
Distillate	2.3433	5.825 million Btu's per barrel*
Residual	1.9771	6.287 million Btu's per barrel*
Coal	1.10307	22.800 million Btu's per short ton

* 42 gallons per barrel

Appendix A-1 (cont'd) - Electric Sector

For purposes of this project, the New England electric sector exists only to provide electricity to the manufacturing, commercial (including street lighting), and residential sectors in New England. Some abstractions are necessary.

Table A-1-4. 1974 Electricity Costs and Revenues

	Total (millions of '74 \$)	Unit ('74 \$/kWh)	Use (10 ¹² Btu)
Energy Cost	941.93	1.4146	
Labor Cost	257.50	0.3867	
Fixed Capital Charge	1068.70	1.6049	
Other Variable Cost	150.21	0.2256	
Revenues	2418.34	3.6318	
Manufacturing	562.30	2.8100	68.28
Comm. Services	804.77	3.9256	69.95
Residential	1051.75	4.0312	89.02

Post-1974, these major changes in "base-load" capacity are expected to occur:

Table A-1-5.

1) Millstone II in 1975	909 MW of capacity
2) Middletown 1-3 (converted to coal in 1980)	422 MW of capacity
3) Brayton Point (converted to coal in 1981)	1162 MW of capacity
4) Mt. Tom (converted to coal in 1982)	136 MW of capacity
5) Seabrook in 1984	1194 MW of capacity

Appendix A-1 (cont'd)

Between 1974 and 1985, all additions to generating capacity (and accompanying transmission capacity) increase the total assets in place. The fixed capital charge represents 18% of the nominal "historical" cost of assets, as projected into the future. Capital costs of equipment are similar to Dept. of Energy estimates.

Table A-1-6.

	<u>Equipment Costs</u> (in 1974 \$)
Transmission Capacity	\$450/kW
Nuclear Generation	\$612/kW
Retro Coal Conversion	\$120/kW
Oil Generation	\$297/kW
Coal w/Scrubber	\$516/kW
Coal w/o Scrubber	\$415/kW
Hydroelectric	\$356/kW
Sub-Bituminous	\$452/kW
Lignite	\$502/kW
Refuse	\$400/kW
Scrubbing Costs	\$ 11/kW

For equipment cost inflation:

1974 deflator	=	1.000
1978 deflator	=	1.300
1980 deflator	=	1.445
1985 deflator	=	1.855

Appendix A-1 (cont'd)

Thus, a "snapshot" of electric utility capacity, assets, and fixed capital charges for 1980 and 1985 can be formed :

Table A-1-7 .

	<u>Hydro</u>	<u>Nuclear</u>	<u>Special Cost</u>	<u>Other</u>	<u>Assets</u>	<u>Fixed Charge</u>
	<u>(capacity in megawatts)</u>				<u>(in current \$ millions)</u>	
1974	2619	3469	0	12309	5937.2	1068.7
1980	2631	4378	422	14096	9377.2	1687.9
1985 : No Seabrook	2689	4378	1720	14200	11647.2	2906.5
Basic	2689	5572	1720	14200	13837.8	2490.8
High Price	2689	5572	1720	14200	16028.3	2885.1
Cogeneration	2689	5572	540	14800	13487.2	2427.7

Base Load - Trillions of Btu's of Electricity Produced and (Load Factor)

	<u>Hydro</u>	<u>Nuclear</u>	<u>Special Coal</u>	<u>Re-Purchased Cogeneration</u>
1974	15.78 (0.2016)	57.72 (0.557)	0	
1980	15.85 (0.2016)	85.05 (0.65)	7.5 (0.60)	
1985 : No Seabrook	16.20 (0.2016)	85.05 (0.65)	30.8 (0.60)	
Basic	16.20 (0.2016)	108.25 (0.65)	10.3 (0.60)	
Cogeneration	16.20 (0.2016)	108.25 (0.65)	10.3 (0.60)	18.6

Appendix A-1 (cont'd)

As a result of the modeling mechanism which combines all of the base load generation into one category, a base-load fuel price for the electric sector must be calculated as a weighted average of all base-load fuels. These base-load fuel prices are given below.

Table A-1-8.

	<u>1974</u>	<u>1980</u>	<u>1985</u>
	<u>(current ¢/kWh)</u>		
Basic price	0.212	0.564	1.151
CON30: No Seabrook	0.212	0.564	1.193
High prices	0.212	0.7687	1.7412
Low prices	0.212	0.4593	0.7769
Cogeneration	0.212	0.564	1.117
	<u>(constant 1974 ¢/kWh)</u>		
Basic price	0.212	0.3903	0.6205
CON30: No Seabrook	0.212	0.3903	0.6431
High prices	0.212	0.5320	0.9387
Low prices	0.212	0.3178	0.4188
Cogeneration	0.212	0.3903	0.6022

Appendix A-2. New England "EXTRAP" Economic Projection Inputs and Implied Growth Rates
(per annum, continuously compounded)

<u>Variable (units)</u>	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
U.S. GNP Deflator	1.000	6.135%	1.445	5.000%	1.855
New England population (millions)	12.15	0.790%	12.74	0.800%	13.26
Labor force participation rate	.4538	0.900%	.4790	0.819%	.4990
New England labor force (millions)	5.514	1.689%	6.102	1.620%	6.617
Vehicles per capita	.5772	1.700%	.6392	1.700%	.6959
Vehicles (millions)	7.013	2.500%	8.143	2.500%	9.228
Dwellings per capita	.3235	0.600%	.3353	0.600%	.3455
Dwellings (millions)	3.930	1.391%	4.272	1.400%	4.581
Wages					
(current \$/hr)	4.10	7.634%	6.482	6.500%	8.971
('74 \$/hr)	4.10	1.500%	4.486	1.500%	4.836
Disposable Income (GRP)					
(millions current \$)	77006	9.635%	137275	8.500%	209974
(millions '74 \$)	77006	3.500%	95000	3.500%	113193
G+E-M (sector demand levels in current \$ millions)					
Agr., mining, construction	2801.32	9.835%	5054.05	8.500%	7730.63
Manufacturing	3533.0	9.835%	6374.13	8.500%	9749.81
Comm. transportation	342.4	9.835%	617.75	8.500%	944.90
Comm. services	10692.3	9.835%	19290.7	8.500%	29506.87
Res. transportation	0	--	0	--	0
Res. energy services	0	--	0	--	0
Aggregate relative sectoral wage factors (wage in sector/wage in region) ⁻¹					
Agr., mining, construction	.8499	-1.500%	.7767	-1.500%	.7206
Manufacturing	.8509	-1.500%	.7777	-1.500%	.7215
Comm. transportation	.8595	-1.500%	.7855	-1.500%	.7288
Comm. services	1.1375	-1.500%	1.0396	-1.500%	.9645
Res. transportation	1.0	-1.500%	.9139	-1.500%	.8479
Res. energy services	1.0	-1.500%	.9139	-1.500%	.8479
Electric utility	.63667	-1.500%	.58187	-1.500%	.53983
Other employment (in millions)	1.23	3.480%	1.5156	3.095%	1.7693
Exogenous increase in electricity use (as a fraction of previous total)					
Agr., mining, construction	0	--	0	--	0
Manufacturing	0	0.865%	.0527	0.855%	.0437
Comm. transportation	0	--	0	--	0
Comm. services	0	--	0	--	0
Res. transportation	0	--	0	--	0
Res. energy services	0	1.026%	.0635	1.031%	.0529

Appendix A-2 (cont'd)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Exogenous conservation (as a fraction of previous total)					
Agr., mining, construction	0	--	0	--	0
Manufacturing	0	--	0	--	0
Comm. transpotation	0	--	0	---	0
Comm. services	0	--	0	--	0
Res. transportation	0	--	0	--	0
Res. energy services	0	--	0	--	0

Basic energy prices (as outlined in Appendix A-1)

Basic electricity prices (as outlined in Appendix A-1)

This scenario uses no price-induced conservation and no automatic capital income adjustment.

Appendix A-3. Input Changes Made for "CON20" (from EXTRAP - Appendix A-1)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Capital Income Adjustment Terms (as a fraction of BASE-YEAR payment)					
Agr., mining, construction	1.0	-	1.0	-	1.0
Manufacturing	1.0	-	1.004398	-	1.008797
Comm. transportation	1.0	-	1.0	-	1.0
Comm. services	1.0	-	1.00156	-	1.00312
Res. transportation	1.0	-	1.0	-	1.0
Res. energy services	1.0	-	1.0	-	1.0

Conservation Terms (as a fraction of previous total)

Agr., mining, construction	0	-	0	-	-
Manufacturing	0	-	0.0818	-	0.0891
Comm. transportation	0	-	0.121	-	0.048
Comm. services	0	-	0.10	-	0.108
Res. transportation	0	-	0.1526	-	0.1046
Res. energy services	0	-	0.10	-	0.108

Appendix A-4. Input Changes Made for CON30 (from EXTRAP)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Capital Income Adjustment Terms (as a fraction of BASE-YEAR payment)					
Agr., mining, construction	1.0	-	1.0	-	1.0
Manufacturing	1.0	-	1.006597	-	1.013915
Comm. transportation	1.0	-	1.0	-	1.0
Comm. services	1.0	-	1.00351	-	1.00703
Res. transportation	1.0	-	1.0	-	1.0
Res. energy services	1.0	-	1.0	-	1.0

Conservation terms (as a fraction of previous total)

Agr., mining, construction	0	-	0	-	0
Manufacturing	0	-	0.10	-	0.108
Comm. transportation	0	-	0.121	-	0.048
Comm. services	0	-	0.15	-	0.175
Res. transportation	0	-	0.1526	-	0.1046
Res. energy services	0	-	0.15	-	0.175

Appendix A-5. Input Changes Made for "CON30:NO SEABROOK" (from EXTRAP)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>1980-85 Growth</u>	<u>1985</u>
Capital Income Adjustment Terms (as a fraction of BASE-YEAR payment)					
Agr., mining, construction	1.0	-	1.0	-	1.0
Manufacturing	1.0	-	1.006597	-	1.013195
Comm. transportation	1.0	-	1.0	-	1.0
Comm. services	1.0	-	1.00351	-	1.00703
Res. transportation	1.0	-	1.0	-	1.0
Res. energy services	1.0	-	1.0	-	1.0
Conservation Terms (as a fraction of previous total)					
Agr., mining, construction	0	-	0	-	0
Manufacturing	0	-	0.10	-	0.108
Comm. transportation	0	-	0.121	-	0.048
Comm. services	0	-	0.15	-	0.175
Res. transportation	0	-	0.1526	-	0.1046
Res. energy services	0	-	0.15	-	0.175
Base Electricity Generation (trillions of Btu's)*					
	73.50	-	108.4	-	131.05
Base Electricity Fuel Cost (nominal ¢/kWh)*					
	0.212	-	0.564	-	1.193
Electricity Capital Charge (millions nominal \$)*					
	1068.7	-	1687.9	-	2096.5

* As outlined in Appendix A-1

Appendix A-6. Input Changes Made for "BASE" (from EXTRAP)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Exogenous Conservation (as a fraction of previous total)					
Agr., mining, construction	0	-	0	-	0
Manufacturing	0	-	0	-	0
Comm. transportation	0	-	0	-	0
Comm. services	0	-	0	-	0
Res. transportation	0	-	0.08	-	0.076
Res. energy services	0	-	0	-	0

This scenario uses price-induced conservation in a direct elasticity model and automatically adjusts capital income for manufacturing and commercial services.

Appendix A-7. Input Changes Made for "FEA BASE" (from BASE)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Exogenous increase in electricity use (as a fraction of previous total)					
Agr., mining, construction	0	-	0	-	0
Manufacturing	0	-	0.142	-	0.117
Comm. transportation	0	-	0	-	0
Comm. services	0	-	0.142	-	0.117
Res. transportation	0	-	0	-	0
Res. energy services	0	-	0	-	0

This scenario uses the FEA two-step model of price-induced energy response, and automatically adjusts capital income in the manufacturing and commercial services sectors.

Appendix A-8. Input Changes Made for "HIGH GROWTH" (from BASE)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Wages					
(current \$/hr)	4.10	7.824%	6.5563	6.403%	9.042
('74 \$/hr)	4.10	1.689%	4.537	1.403%	4.874
Disposable Income (GRP)					
(millions current \$)	77006	10.205%	142051	8.210%	214151
(millions 1974 \$)	77006	4.070%	98305	3.210%	115445
G+E-M (sector demand levels in current \$ millions)					
Agr., mining, construction	2801.32	10.405%	5229.9	8.21%	7884.4
Manufacturing	3533.0	10.405%	6595.9	8.21%	9943.8
Comm. transportation	342.4	10.405%	639.2	8.21%	963.7
Comm. Services	10692.3	10.405%	19961.9	8.21%	30093.9
Aggregate Relative Sectoral Wage Factors (wage in sector/wage in region) ⁻¹					
Agr., mining, construction	.8499	-1.690%	.76795	-1.403%	.7159
Manufacturing	.8509	-1.690%	.7689	-1.403%	.7168
Comm. transportation	.8595	-1.690%	.7766	-1.403%	.7241
Comm. services	1.1375	-1.690%	1.0278	-1.403%	.9582
Res. transportation	1.0	-1.690%	.9035	-1.403%	.8424
Res. energy services	1.0	-1.690%	.9035	-1.403%	.8424
Electric utility	.63667	-1.690%	.5753	-1.403%	.5363
Labor Force Participation					
Rate	.4538	1.0221%	.4825	0.7525%	.5010
Electricity Time Trend (as a fraction of previous total)					
Res. energy services	0	0	0.0739	-	.0485

Appendix A-9. Input Changes Made for "LOW GROWTH" (from BASE)

	<u>1974</u>	<u>74-80 Growth</u>	<u>1980</u>	<u>80-85 Growth</u>	<u>1985</u>
Wages					
(current \$/hr)	4.10	7.618%	6.476	6.2767%	8.863
('74 \$/hr)	4.10	1.483%	4.482	1.2767%	4.778
Disposable Income (GRP)					
(millions current \$)	77006	9.587%	136880	7.830%	202742
(millions 1974 \$)	77006	3.452%	94727	2.830%	109149
G+E-M (sector demand levels in current \$ millions)					
Agr., mining, construction	2801.32	9.787%	5039.5	7.830%	7454
Manufacturing	3533.0	9.787%	6355.8	7.830%	9401.5
Comm. transportation	342.4	9.787%	616.0	7.830%	911.1
Comm. services	10692.3	9.787%	19235.2	7.830%	28452.7
Aggregate Relative Sectoral Wage Factors (wage in sector/wage in region) ⁻¹					
Agr., mining, construction	.8499	-1.484%	.7775	-1.2767%	.7294
Manufacturing	.8509	-1.484%	.7783	-1.2767%	.7303
Comm. transportation	.8595	-1.484%	.7853	-1.2767%	.7377
Comm. services	1.1375	-1.484%	1.0394	-1.2767%	.9763
Res. transportation	1.0	-1.484%	.9137	-1.2767%	.8583
Res. energy services	1.0	-1.484%	.9137	-1.2767%	.8583
Electric Utility	.63667	-1.484	.5817	-1.2767%	.5464
Labor Force Participation Rate	.4538	.8854	.47856	.6071%	.49331
Electricity Time Trend (as a fraction of previous total)					
Res. energy services	0	--	.0626	-	.0427

Appendix A-10Input Changes Made for "HIGH PRICES" (from BASE)

This scenario uses the high energy prices as outlined in Appendix A-1.

Input Changes Made for "FEA HIGH PRICES" (from FEA BASE)

This scenario uses the high prices outlined in Appendix A-1.

Input Changes Made for "HIGH PRICE, LOW PATH" (from BASE)

This scenario uses the high prices for 1985 and the low prices for 1980, as outlined in Appendix A-1. This scenario uses price-induced conservation in a direct elasticity model, and automatically adjusts capital income for manufacturing and services.

Input Changes Made for "LOW PRICES" (from BASE)

This scenario uses the set of low prices for 1980 and 1985 as outlined in Appendix A-1.

Appendix A-11. Inputs to Cogeneration (Changes from Base, 1985)

	<u>I N D U S T R I A L</u>		<u>C O M M E R C I A L</u>	
	<u>Distillate</u>	<u>Residual</u>	<u>Distillate</u>	<u>Residual</u>
Capacity (MW)	363	1062	83	171
Energy:				
Oil burned **	31.7	80.7	7.2	12.5
Annual elec. production **	8.68	25.38	1.98	4.08
Own use **	4.34	12.69	0.79	1.63
Sent back **	4.34	12.69	1.19	2.45
Steam energy provided	15.68	31.90	3.39	4.80
Oil that would have been burned previously for that steam energy **	19.05	38.70	4.16	5.88
Net additional oil burned for electricity **	12.65	42.0	3.04	6.62
Nominal annual capital charge	\$129.0 million		\$23.0 million	
Credit for resold electricity	\$134.3 million		\$33.6 million	
Nominal annual savings *	\$ 5.30 million		\$10.6 million	
Annual savings (in '74 \$)*	\$ 2.86 million		\$ 5.71 million	

** Trillions of Btu's

* Does not include the increase in oil costs, nor the reduction in electricity costs.

As a result of cogeneration, the following changes occur in the electric utility sector in 1985:

(1) The utility purchases 18.6 trillion Btu's of base capacity from cogenerators, at a total cost of \$167.9 million (1985) dollars.

(2) Brayton Point is not converted to coal. This eliminates approximately two-thirds of base coal capacity and reduces capital cost charges by \$63.06 million (1985) dollars. The new fixed charge for 1985 is \$2427.7 million (1985) dollars.

Appendix A-12. Inputs for Solar (Changes from BASE 1985)

Changes in energy use in trillions of Btu's (reductions):

	<u>Elec.</u>	<u>Dist.</u>	<u>Residual</u>	<u>Exotic</u>	<u>Cost*</u>
Residential hot water	(1.96)			1.96	51.0*
Residential space heat	<u>(2.10)</u>	<u>(8.38)</u>		<u>10.48</u>	_____
	(4.06)	(8.38)		12.44	51.0*
Commercial hot water	(.98)	0		.98	31.78*
Commercial space heat	<u>(2.04)</u>	<u>(5.10)</u>	<u>(4.07)</u>	<u>11.21</u>	_____
	(3.02)	(5.10)	(4.07)	12.19	31.78*

* in millions of 1985 \$ per year

The costs of solar equipment were entered as price for an exotic fuel. Price used were \$4.099 per million Btu's for the residential sector and \$2.61 per million Btu's for the service sector.

VIII. Appendix B

In this Appendix, Tables reporting the important results for each simulation case are presented. Table B-1 presents 1974 data as a basis for comparison. Tables B-2 through B-16 present each of the fifteen simulation cases, with one case for each Table. The inputs and assumptions used to project each case are documented in the second section of this report and Appendix A, and case names are defined in those sections. Contents of the Tables should be self-explanatory or described in Table footnotes. Sector and energy form definitions are described in detail in the Task I final report, as well.

Table B-1 : Simulation Results: 1974

	<u>1974</u>
Unemployment Rate (%)	6.63
CPI _{New England} /CPI _{U.S.}	1.00
Property Income*	27.75
Labor Income*	33.70
Electricity Accounts:	
Electricity [ϕ (1974)/kWh]: Average:	3.632
Price: To Manufacturing:	2.810
Electricity Production**	227.2
Nuclear**	57.7
Hydroelectric**	15.8
Fossil Fuel**	153.7
Fossil Fuel Usage**	508.7
Distillate**	10.2
Residual**	451.5
Coal**	47.0

Sector Accounts: 1974

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> [†]
Real Price Index	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Production*	13.63	52.89	3.470	57.15	1.539	2.467	131.1
Value Added*	4.43	20.86	2.030	41.38			68.72
Energy Use**, +	5.04	307.5	227.3	560.6	468.2	635.5	256.1
Electricity**		68.3		70.0		89.0	227.2
Natural Gas**	1.3	44.8		63.4		142.4	263.7
Gasoline**	1.7		185.7	9.0	468.2		664.6
Distillate**	2.1	76.6	41.6	197.3		371.7	699.4
Residual**		111.3		220.6			773.4
Coal**		6.6		0.3		0.6	54.2
Energy Cost ⁺⁺	11.8	1045	711.	1909.	1539.	2467.	

See Table B-2 for Footnotes.

Table B-2 : Simulation Results: EXTRAP

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	6.358	5.807
CPI _{New England} /CPI _{U.S.}	1.054	1.098
Property Income*	32.76	37.72
Labor Income*	43.09	53.08
Electricity Accounts:		
Electricity [ϵ (1974)/kWh]: Average:	3.659	3.632
Price: To Manufacturing:	3.266	3.245
Electricity Production**	266.9	306.6
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.2
Fossil Fuel**	166.0	182.15
Fossil Fuel Usage**	546.4	592.1
Distillate**	10.5	10.0
Residual**	465.1	444.0
Coal**	70.8	138.1

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.058	1.063	1.101	1.038	1.319	1.033	1.054
Production*	15.32	60.63	3.891	68.46	1.735	2.625	152.7
Value Added*	5.30	25.42	2.429	51.36			84.51
Energy Use**, ⁺	5.6	356.6	259.7	671.6	527.9	682.3	2892.
Electricity**		82.4		83.8		100.7	266.9
Natural Gas**	1.4	51.4		76.0		151.6	280.3
Gasoline**	1.9		212.1	10.8	527.9		752.8
Distillate**	2.3	87.8	47.6	236.3		395.5	780.0
Residual**		127.6		264.2			856.9
Coal**		7.5		0.4		0.7	69.4

Energy Cost⁺⁺ 16.7 142.3 1046. 2402. 2289. 2712.

Table B-2

Page 2

EXTRAP

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.107	1.115	1.160	1.072	1.445	1.089	1.098
Production*	16.98	68.22	4.360	79.67	1.949	2.779	174.0
Value Added*	6.16	30.14	2.843	61.68			100.8
Energy Usage**, ⁺	6.3	405.3	290.9	781.6	592.9	727.9	3245.
Electricity**		96.8		97.5		112.3	306.6
Natural Gas**	1.6	57.8		88.4		160.5	308.2
Gasoline**	2.1		237.7	12.6	592.9		845.4
Distillate**	2.6	98.8	53.3	275.0		418.7	858.4
Residual**		143.5		307.5			895.1
Coal**		8.4		0.5		0.7	147.8
Energy Cost ⁺⁺	19.9	1661.	1278.	2857.	2817.	3027.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B- 3: Simulation Results: CON20

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	5.702	4.673
CPI _{New England} /CPI _{U.S.}	1.043	1.077
Property Income*	33.16	38.55
Labor Income*	43.53	54.02
Electricity Accounts:		
Electricity [ϕ (1974)/kWh]: Average:	3.729	3.767
Price: To Manufacturing:	3.330	3.370
Electricity Production**	244.4	254.3
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	136.0	129.8
Fossil Fuel Usage**	471.9	419.1
Distillate**	9.0	6.5
Residual**	399.0	390.5
Coal**	63.9	122.1

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.054	1.059	1.066	1.034	1.118	.9376	1.043
Production*	15.46	61.25	3.924	69.14	1.781	2.658	154.2
Value Added*	5.345	25.71	2.450	51.93			85.44
Energy Use**, +	5.7	330.8	230.2	610.5	459.0	621.7	2594.
Electricity**		76.4		76.2		91.8	244.4
Natural Gas**	1.4	47.6		69.1		138.1	256.3
Gasoline**	2.0		188.0	9.8	459.0		658.8
Distillate**	2.3	81.4	42.1	214.8		360.4	710.2
Residual**		118.3		240.2			757.6
Coal**		7.0		0.4		0.6	71.9
Energy Cost ⁺⁺	16.8	1334	927.5	2201	1990	2492	

Table B-3
Page 2

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.101	1.107	1.108	1.065	1.096	.8887	1.077
Production*	17.24	69.45	4.42	81.11	2.039	2.841	177.1
Value Added*	6.257	30.76	2.873	62.90			102.8
Energy Usage**, ⁺	6.4	345.1	246.8	638.8	470.7	597.4	2626.
Electricity**		82.4		79.7		92.2	254.3
Natural Gas**	1.6	49.2		72.3		131.7	254.8
Gasoline**	2.2		201.6	10.3	470.7		684.8
Distillate**	2.6	84.1	45.2	224.8		343.7	706.9
Residual**		122.2		251.3			664.0
Coal**		7.3		0.4		0.6	130.3
Energy Cost ⁺⁺	20.2	1444.	1084.	2369.	2236.	2524.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B-4 : Simulation Results: CON30

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	5.583	4.438
CPI _{New England} /CPI _{U.S.}	1.041	1.072
Property Income*	33.28	38.84
Labor Income*	43.61	54.22
Electricity Accounts:		
Electricity [ϕ (1974)/kWh]: Average:	3.765	3.851
Price: To Manufacturing:	3.367	3.456
Electricity Production**	234.0	230.1
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	133.1	105.4
Fossil Fuel Usage**	437.7	389.5
Distillate**	8.3	5.0
Residual**	368.6	219.7
Coal**	60.8	114.8

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.054	1.058	1.066	1.033	1.118	0.890	1.041
Production*	15.49	61.36	3.931	69.28	1.785	2.664	154.5
Value Added*	5.35	25.78	2.454	52.09			85.68
Energy Use**, ⁺	5.7	324.8	230.6	577.7	460.0	588.5	2499.
Electricity**		75.1		72.1		86.9	234.0
Natural Gas**	1.4	46.8		65.4		130.8	244.3
Gasoline**	2.0		188.3	9.3	460.0		659.7
Distillate**	2.3	80.0	42.2	203.3		341.2	677.3
Residual**		116.2		227.3			712.2
Coal**		6.9		0.3		0.6	68.5

Energy Cost⁺⁺ 16.8 1318. 929. 2092. 1995. 2370.

Table B-4
Page 2

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> [†]
Real Price Index	1.100	1.107	1.108	1.063	1.096	0.785	1.072
Production*	17.30	69.70	4.435	81.44	2.048	2.854	177.8
Value Added*	6.277	30.91	2.883	63.30			103.4
Energy Usage**, [†]	6.4	332.5	247.7	560.2	472.8	524.3	2409.
Electricity**		79.4		69.9		80.9	230.1
Natural Gas**	1.6	47.4		63.4		115.6	227.9
Gasoline**	2.2		202.3	9.0	472.8		686.3
Distillate**	2.6	81.0	45.4	197.1		301.6	632.6
Residual**		117.7		220.4			557.9
Coal**		7.0		0.3		0.5	122.6
Energy Cost ⁺⁺	20.3	1411.	1088.	2098.	2246.	2239.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

[†] Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

⁺⁺ In millions of 1974 dollars

Table B- 5: Simulation Results: CON30NS

	<u>1985</u>						
Unemployment Rate (%)	4.383						
CPI _{New England} /CPI _{U.S.}	1.071						
Property Income*	38.87						
Labor Income*	54.27						
Electricity Accounts:							
Electricity [ϕ (1974)/kWh]: Average:	3.714						
Price: To Manufacturing:	3.334						
Electricity Production**	230.3						
Nuclear**	85.05						
Hydroelectric**	16.20						
Fossil Fuel**	129.0						
Fossil Fuel Usage**	416.9						
Distillate**	6.5						
Residual**	288.5						
Coal**	121.9						
Sector Accounts:	<u>1985</u>						
<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> [†]
Real Price Index	1.100	1.106	1.108	1.063	1.096	.7727	1.071
Production*	17.31	69.76	4.439	81.50	2.050	2.856	177.9
Value Added*	6.282	30.94	2.885	63.350			103.5
Energy Use**, [†]	6.4	332.7	247.8	560.7	473.3	524.8	2465.
Electricity**		79.4		70.0		80.9	230.3
Natural Gas**	1.6	47.4		63.4		115.7	228.1
Gasoline**	2.2		202.5	9.0	473.3		687.0
Distillate**	2.6	81.1	45.4	197.3		301.9	634.8
Residual**		117.8		220.6			626.9
Coal**		7.0		0.3		0.5	129.7
Energy Cost ^{††}	20.3	1384.	1089.	2071.	2248.	2207.	

See Table B-2 for Footnotes.

Table B-6 : Simulation Results: BASE

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	5.913	5.108
CPI _{New England} /CPI _{U.S.}	1.047	1.086
Property Income*	33.02	38.19
Labor Income*	43.37	53.63
Electricity Accounts:		
Electricity [¢(1974)/kWh]: Average:	3.640	3.616
Price: To Manufacturing:	3.240	3.217
Electricity Production**	274.1	314.3
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	173.2	189.9
Fossil Fuel Usage**	570.0	617.6
Distillate**	11.0	10.5
Residual**	486.0	466.6
Coal**	73.0	140.5

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> [†]
Real Price Index	1.055	1.059	1.066	1.037	1.113	1.017	1.047
Production*	15.42	61.05	3.911	68.88	1.774	2.647	153.7
Value Added*	5.33	25.62	2.441	51.71			85.10
Energy Use**, ⁺	5.7	331.5	231.5	633.0	455.3	669.0	2739.
Electricity**		80.1		89.4		104.5	274.1
Natural Gas**	1.4	53.6		73.7		160.1	288.8
Gasoline**	2.0		183.7	10.9	455.3		651.8
Distillate**	2.3	65.4	47.8	238.2		385.6	750.3
Residual**		124.8		220.3			831.2
Coal**		7.6		0.4		0.7	81.6
Energy Cost ⁺⁺	16.8	1333.	924.	2356.	1974.	2692.	

Table B-6
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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL +</u>
Real Price Index	1.102	1.109	1.109	1.071	1.093	1.049	1.086
Production*	17.14	68.99	4.390	80.47	2.023	2.817	175.8
Value Added*	6.22	30.54	2.854	62.35			102.0
Energy Usage**, +	6.3	356.2	248.9	711.0	465.4	703.4	2950.
Electricity**		90.6		108.6		115.1	314.3
Natural Gas**	1.6	60.5		80.6		174.5	317.2
Gasoline**	2.2		195.3	12.7	465.4		675.5
Distillate**	2.6	54.2	53.7	281.0		402.5	804.4
Residual**		142.3		227.6			836.5
Coal**		8.6		0.5		0.7	150.2
Energy Cost++	20.1	1473.	1078.	2781.	2211.	2955.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B-7 : Simulation Results: FEABS

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	6.080	5.368
CPI ^{New England} /CPI ^{U.S.}	1.048	1.088
Property Income*	32.88	37.95
Labor Income*	43.26	53.41
Electricity Accounts:		
Electricity [ϵ (1974)/kWh]: Average:	3.605	3.578
Price: To Manufacturing:	3.216	3.198
Electricity Production**	287.7	334.2
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.2
Fossil Fuel**	186.8	209.8
Fossil Fuel Usage**	615.2	683.6
Distillate**	11.9	11.9
Residual**	526.1	525.1
Coal**	77.2	146.6

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.057	1.062	1.067	1.039	1.117	0.984	1.048
Production*	15.38	60.89	3.901	68.69	1.768	2.748	153.4
Value Added*	5.32	25.53	2.435	51.54			84.82
Energy Use**, ⁺	5.7	356.6	229.4	668.3	455.5	687.3	2839.
Electricity**		87.9		99.1		100.8	287.3
Natural Gas**	1.4	51.1		74.3		162.4	289.2
Gasoline**	1.9		187.4	10.8	455.5		655.6
Distillate**	2.3	86.5	42.0	222.9		390.2	755.8
Residual**		124.4		260.8			911.3
Coal**		6.8		0.3		0.6	84.9

Energy Cost⁺⁺ 16.7 1450. 924. 2509. 1975. 2704.

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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> +
Real Price Index	1.105	1.114	1.111	1.074	1.100	1.008	1.088
Production*	17.08	68.68	4.372	80.14	2.012	3.019	175.3
Value Added*	6.20	30.35	2.842	62.05			101.4
Energy Usage**, +	6.3	406.4	246.2	770.4	465.9	743.0	3143.
Electricity**		105.8		116.3		112.1	334.2
Natural Gas**	1.6	56.9		84.0		178.8	321.3
Gasoline**	2.2		201.1	12.5	465.9		681.7
Distillate**	2.6	96.2	45.1	253.4		415.9	825.0
Residual**		140.		303.8			969.0
Coal**		7.4		0.4		0.6	155.0
Energy Cost++	20.0	1714.	1082.	2966.	2213.	3044.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction
MNF = Manufacturing
CMTR= Commercial transportation
SER = Services
RSTR= Residential transportation
RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B- 8: Simulation Results: HIGRO

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	5.321	4.814
CPI _{New England} /CPI _{U.S.}	1.052	1.090
Property Income*	34.06	38.85
Labor Income*	45.16	54.93
Electricity Accounts:		
Electricity [¢(1974)/kWh]: Average:	3.626	3.612
Price: To Manufacturing:	3.228	3.215
Electricity Production**	281.1	318.0
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	180.2	193.6
Fossil Fuel Usage**	593.2	630.0
Distillate**	11.4	10.8
Residual**	506.7	477.6
Coal**	75.1	141.6

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.062	1.066	1.071	1.042	1.113	1.020	1.052
Production*	15.74	62.62	4.007	71.25	1.785	2.656	158.1
Value Added*	5.48	26.49	2.516	53.74			88.22
Energy Use**, ⁺	5.8	340.1	237.1	653.5	458.0	672.5	2787.
Electricity**		82.2		92.7		106.1	281.1
Natural Gas**	1.4	55.0		76.2		160.5	293.2
Gasoline**	2.0		188.2	11.3	458.0		659.4
Distillate**	2.4	67.1	49.0	246.4		386.9	763.1
Residual**		128.0		226.5			861.2
Coal**		7.8		0.4		0.7	84.0
Energy Cost ⁺⁺	17.1	1365.	946.	2433.	1986.	2710.	

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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.108	1.114	1.112	1.074	1.093	1.049	1.090
Production*	17.34	69.95	4.449	81.98	2.028	2.820	178.6
Value Added*	6.33	31.14	2.904	63.74			104.1
Energy Usage**, ⁺	6.4	361.2	252.2	723.5	466.5	704.1	2981.
Electricity**		91.9		110.7		115.4	318.0
Natural Gas**	1.6	61.3		82.1		174.6	319.6
Gasoline**	2.2		197.9	13.0	466.5		679.6
Distillate**	2.6	54.9	54.4	286.3		402.8	811.8
Residual**		144.3		230.9			852.8
Coal**		8.7		0.5		0.7	151.5
Energy Cost ⁺⁺	20.3	1493.	1092.	2831.	2216.	2959.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction
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CMTR= Commercial transportation
SER = Services
RSTR= Residential transportation
RES = Residential energy services

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++ In millions of 1974 dollars

Table B-9 : Simulation Results: LOGRO

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	6.010	5.332
CPI _{New England} /CPI _{U.S.}	1.046	1.079
Property Income*	32.93	36.96
Labor Income*	43.22	51.38
Electricity Accounts:		
Electricity [ϕ (1974)/kWh]: Average:	3.641	3.627
Price: To Manufacturing:	3.241	3.227
Electricity Production**	273.5	306.1
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	172.6	181.7
Fossil Fuel Usage**	568.0	590.6
Distillate**	10.9	10.0
Residual**	484.3	442.6
Coal**	72.8	138.0

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL*</u>
Real Price Index	1.054	1.058	1.066	1.037	1.113	1.017	1.046
Production*	15.39	60.92	3.903	68.68	1.773	2.646	153.3
Value Added*	5.32	25.55	2.435	51.54			84.84
Energy Use**,+	5.7	330.8	231.0	631.3	455.0	668.7	2726.
Electricity**		79.9		89.2		104.4	273.5
Natural Gas**	1.4	53.5		73.5		160.0	288.5
Gasoline**	1.9		183.3	10.9	455.0		651.1
Distillate**	2.3	65.2	47.7	237.5		385.5	749.2
Residual**		124.6		219.8			828.7
Coal**		7.6		0.4		0.7	81.4
Energy Cost ⁺⁺	16.8	1330.	922.	2350.	1973.	2690.	

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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL +</u>
Real Price Index	1.095	1.101	1.103	1.065	1.093	1.045	1.079
Production*	16.76	67.16	4.279	77.65	2.011	2.808	170.7
Value Added*	6.04	29.48	2.763	59.85			98.13
Energy Usage**, +	6.2	346.7	242.6	687.3	462.7	700.	2885.
Electricity**		88.1		104.6		113.4	306.1
Natural Gas**	1.5	58.9		77.9		174.1	312.4
Gasoline**	2.1		190.3	12.3	462.7		667.4
Distillate**	2.5	52.7	52.3	271.2		401.2	789.9
Residual**		138.6		221.0			802.1
Coal**		8.4		0.4		0.7	147.5
Energy Cost++	19.7	1435.	1050.	2688.	2198.	2935.	

*. in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction
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SER = Services
RSTR= Residential transportation
RES = Residential energy services

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++ In millions of 1974 dollars

Table B-10: Simulation Results: HIPRI

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	6.036	5.825
CPI _{New England} /CPI _{U.S.}	1.049	1.098
Property Income*	32.97	37.87
Labor Income*	43.30	53.08
Electricity Accounts:		
Electricity [ϵ (1974)/kWh]: Average:	3.750	4.301
Price: To Manufacturing:	3.339	3.830
Electricity Production**	271.0	292.6
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	171.0	168.2
Fossil Fuel Usage**	559.9	545.8
Distillate**	10.7	9.1
Residual**	477.1	402.9
Coal**	72.1	133.8

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.056	1.060	1.068	1.038	1.125	1.034	1.049
Production*	15.39	60.94	3.905	68.75	1.769	2.641	153.4
Value Added*	5.32	25.58	2.438	51.62			84.96
Energy Use**, ⁺	5.7	326.4	229.3	628.0	451.4	659.0	2697.
Electricity**		79.3		89.0		102.7	271.0
Natural Gas**	1.4	53.7		71.5		159.7	286.3
Gasoline**	1.9		181.6	10.9	451.4		645.8
Distillate**	2.3	61.3	47.7	239.2		383.0	744.2
Residual**		124.5		217.1			818.7
Coal**		7.6		0.4		0.7	80.7
Energy Cost ⁺⁺	17.2	1355.	931.	2411.	1991.	2731.	

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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.107	1.116	1.123	1.078	1.163	1.180	1.098
Production*	16.99	68.29	4.350	79.62	1.988	2.783	174.0
Value Added*	6.17	30.28	2.828	61.71			101.0
Energy Usage**, ⁺	6.3	322.1	235.3	681.6	442.7	670.0	2766.
Electricity**		85.4		104.4		102.7	292.6
Natural Gas**	1.6	62.1		67.2		172.8	302.8
Gasoline**	2.1		182.2	12.6	442.7		639.7
Distillate**	2.6	26.8	53.2	287.3		385.8	764.8
Residual**		140.2		209.5			752.7
Coal**	8.5			0.5		0.7	143.5
Energy Cost ⁺⁺	22.9	1600.	1124.	3153.	2313.	3282.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B-11: Simulation Results: FEHP

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	6.229	6.187
CPI _{New England} /CPI _{U.S.}	1.051	1.102
Property Income*	32.82	37.51
Labor Income*	43.16	52.77
Electricity Accounts:		
Electricity [ϵ (1974)/kWh]:		
Average:	3.710	4.221
To Manufacturing:	3.310	3.774
Electricity Production**	285.7	320.8
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.20
Fossil Fuel**	184.8	196.4
Fossil Fuel Usage**	608.3	639.2
Distillate**	11.7	11.0
Residual**	520.1	485.7
Coal**	76.5	142.5

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.058	1.064	1.070	1.041	1.130	1.011	1.051
Production*	15.35	60.76	3.894	68.54	1.762	2.741	153.0
Value Added*	5.31	25.47	2.431	51.43			84.64
Energy Use**,†	5.7	354.1	226.9	663.4	451.6	682.7	2816.
Electricity**		87.3		98.4		100.0	285.7
Natural Gas**	1.4	50.5		73.1		160.6	285.6
Gasoline**	1.9		185.3	10.7	451.6	11.7	649.6
Distillate**	2.3	86.0	41.5	221.7		388.4	751.7
Residual**		123.6		259.2			903.0
Coal**		6.7		0.3		0.6	84.1

Energy Cost ⁺⁺	17.1	1483.	931.	2654.	1991.	2770.
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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u>
Real Price Index	1.111	1.123	1.126	1.081	1.176	1.166	1.102
Production*	16.90	67.86	4.326	79.17	1.972	2.976	173.2
Value Added*	6.133	29.99	2.812	61.31			100.2
Energy Usage**, +	6.2	391.3	231.6	740.4	443.8	716.2	3003.
Electricity**		101.9		111.4		107.6	320.8
Natural Gas**	1.6	53.5		72.2		168.6	300.9
Gasoline**	2.1		189.2	12.0	443.8		647.2
Distillate**	2.5	93.4	42.4	246.0		405.1	800.4
Residual**		135.8		293.4			914.9
Coal**		6.7		0.4		0.6	150.1
Energy Cost++	22.8	1948.	1125.	3346.	2319.	3469.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B-12: Simulation Results: LOPRI

	<u>1980</u>	<u>1985</u>
Unemployment Rate (%)	5.838	4.369
CPI ^{New England} /CPI ^{U.S.}	1.046	1.080
Property Income*	33.05	38.36
Labor Income*	43.42	53.89
Electricity Accounts:		
Electricity [¢(1974)/kWh]: Average:	3.585	3.450
Price: To Manufacturing:	3.191	3.069
Electricity Production**	276.4	320.8
Nuclear**	85.05	108.25
Hydroelectric**	15.85	16.2
Fossil Fuel**	175.5	196.4
Fossil Fuel Usage**	577.7	639.1
Distillate**	11.1	11.0
Residual**	492.9	485.6
Coal**	73.7	142.5

Sector Accounts: 1980

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.054	1.059	1.063	1.036	1.094	1.009	1.046
Production*	15.43	61.11	3.914	68.95	1.779	2.650	153.8
Value Added*	5.33	25.64	2.443	51.76			85.18
Energy Use**, ⁺	5.7	336.1	234.4	634.6	460.3	673.1	2754.
Electricity**		80.5		90.3		105.6	276.4
Natural Gas**	1.4	53.5		73.2		159.5	287.6
Gasoline**	2.0		186.5	10.9	460.3		659.7
Distillate**	2.3	69.7	47.8	238.8		388.0	757.7
Residual**		124.8		221.0			838.7
Coal**		7.6		0.4		0.7	82.4

Energy Cost⁺⁺ 16.5 1329. 914. 2334. 1946. 2674.

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Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL</u> ⁺
Real Price Index	1.100	1.107	1.093	1.068	0.991	1.011	1.080
Production*	17.21	69.32	4.404	80.87	2.052	2.834	176.7
Value Added*	6.25	30.66	2.863	62.66			102.4
Energy Usage**, ⁺	6.4	377.1	267.3	718.4	495.4	726.4	3064.
Electricity**		92.3		109.4		119.1	320.8
Natural Gas**	1.6	60.5		83.8		174.4	320.2
Gasoline**	2.2		213.5	12.8	495.4		723.9
Distillate**	2.6	75.7	53.8	281.2		412.8	837.0
Residual**		140.0		230.8			856.5
Coal**		8.6		0.5		0.7	152.2
Energy Cost ⁺⁺	18.1	1465.	1015.	2648.	2033.	2864.	

* in billions of 1974 dollars

** in trillions of Btu's

*** Sectors are: AMC = Agriculture, Mining & Construction

MNF = Manufacturing

CMTR= Commercial transportation

SER = Services

RSTR= Residential transportation

RES = Residential energy services

+ Column sums may not add to totals due to unreported minor fuels, and row sums may not add to totals due to special treatment of the electric sector.

++ In millions of 1974 dollars

Table B-13: Simulation Results: HIPLOP

	<u>1985</u>
Unemployment Rate (%)	5.837
CPI _{New England} /CPI _{U.S.}	1.098
Property Income*	37.84
Labor Income*	53.07
Electricity Accounts:	
Electricity [ϵ (1974)/kWh]: Average:	4.295
Price: To Manufacturing:	3.824
Electricity Production**	294.6
Nuclear**	108.25
Hydroelectric**	16.2
Fossil Fuel**	170.2
Fossil Fuel Usage**	552.6
Distillate**	9.2
Residual**	408.9
Coal**	134.5

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.107	1.116	1.123	1.078	1.163	1.186	1.098
Production*	16.99	68.27	4.349	79.60	1.988	2.782	174.0
Value Added*	6.16	30.26	2.827	61.69			100.9
Energy Use**, ⁺	6.3	324.9	235.3	681.9	442.6	671.9	2776.
Electricity**		85.9		104.7		104.0	294.6
Natural Gas**	1.6	61.2		67.6		172.2	302.5
Gasoline**	2.1		182.1	12.6	442.6		639.5
Distillate**	2.6	29.2	53.2	286.3		386.8	767.2
Residual**		140.1		210.2			759.3
Coal**		8.5		0.5		0.7	144.1
Energy Cost ⁺⁺	22.9	1612.	1123.	3154.	2313.	3300.	

See Table B-2 for Footnotes.

Table B-14 : Simulation Results: Cogeneration

	<u>1985</u>
Unemployment Rate (%)	5.144
CPI New England/CPI U.S.	1.086
Property Income*	38.24
Labor Income *	53.62

Utility Electricity Accounts

Electric price avg. (1974¢ /kWh)	3.617
Electric price to manuf. (1974¢ /kWh)	3.199
Electricity production**	295.0
Nuclear **	108.25
Hydroelectric **	16.20
Purchased from cogenerators **,+++	18.60
Fossil fuel **	151.95
Utility fossil fuel use **	498.4
Distillate **	9.4
Residual **	415.7
Coal **	73.3

Sector Accounts: 1985

<u>Sector</u> ***	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>Res.</u>	<u>Total</u> ⁺
Real Price Index	1.103	1.109	1.109	1.071	1.093	1.047	1.086
Production*	17.14	68.98	4.389	80.44	2.023	2.817	175.8
Value added*	6.219	30.55	2.853	62.38			102.0
Energy Use**,+	6.33	410.7	248.9	720.3	465.3	703.4	2892.
Total elec.		90.6		108.5		115.4	314.5
Total delivered							
electricity**		34.06		6.06			40.12
Cogen. sent to							
utility+++,**		17.03		3.64			20.67
Natural gas **	1.6	60.5		80.6		174.4	317.0
Gasoline **	2.2		195.2	12.7	465.3		675.4
Distillate**	2.6	66.8	53.6	283.9		402.4	818.7
Residual**		184.3		234.1			834.0
Coal **		8.6		0.5		0.7	83.0
Energy Cost ++	20.1	1309.7	1078.	2736.	2210.	2950.	

+++ = A 10% loss before sale

See Table B-2 for other footnotes.

Table B-15: Simulation Results: COAL

	<u>1985</u>
Unemployment Rate (%)	5.120
CPI _{New England} /CPI _{U.S.}	1.086
Property Income*	38.21
Labor Income*	53.62
Electricity Accounts:	
Electricity [ϕ (1974)/kWh]: Average:	3.615
Price: To Manufacturing:	3.217
Electricity Production**	314.2
Nuclear**	108.25
Hydroelectric**	16.2
Fossil Fuel**	189.8
Fossil Fuel Usage**	617.5
Distillate**	10.5
Residual**	466.5
Coal**	140.5

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL⁺</u>
Real Price Index	1.103	1.109	1.109	1.071	1.093	1.049	1.086
Production*	17.14	68.97	4.389	80.46	2.022	2.816	175.8
Value Added*	6.219	30.55	2.853	62.34			102.0
Energy Use**, +	6.3	356.0	248.9	710.8	465.3	703.2	2949.
Electricity**		90.6		108.6		115.1	314.2
Natural Gas**	1.6	54.1		80.6		174.5	310.7
Gasoline**	2.2		195.2	12.7	465.3		675.4
Distillate**	2.6	54.2	53.6	281.0		402.4	804.2
Residual**		127.2		227.5			821.2
Coal**		30.0		0.5		0.7	171.6

Energy Cost⁺⁺ 20.1 1469. 1078. 2780. 2210. 2955.

See Table B-12 for footnotes.

Table B-16: Simulation Results: SOLAR

	1985
Unemployment Rate (%)	5.105
CPI _{New England} /CPI _{U.S.}	1.085
Property Income*	38.23
Labor Income*	53.64
Electricity Accounts:	
Electricity [ϕ (1974)/kWh]: Average:	3.631
To Manufacturing:	3.234
Electricity Production**	307.2
Nuclear**	108.25
Hydroelectric**	16.2
Fossil Fuel**	182.8
Fossil Fuel Usage**	594.1
Distillate**	10.1
Residual**	445.7
Coal**	138.3

Sector Accounts: 1985

<u>Sector***</u>	<u>AMC</u>	<u>MNF</u>	<u>CM TR</u>	<u>SER</u>	<u>RS TR</u>	<u>RES</u>	<u>TOTAL +</u>
Real Price Index	1.103	1.109	1.109	1.071	1.093	1.036	1.085
Production*	17.14	69.00	4.391	80.48	2.024	2.818	175.9
Value Added*	6.221	30.54	2.854	62.40			102.0
Energy Use**, +	6.3	356.1	249.0	711.1	465.5	703.6	2934.
Electricity**		90.5		105.6		111.1	307.2
Natural Gas**	1.6	60.5		80.6		174.6	317.3
Gasoline**	2.2		195.3	12.7	465.5		675.7
Distillate**	2.6	54.2	53.7	276.0		394.2	790.7
Residual**		142.4		223.6			811.6
Coal**		8.6		0.5		0.7	148.0
Solar				12.2		12.4	24.6
Energy Cost++	20.1	1476.	1078.	2747.	2211.	2920.	

See Table B-12 for footnotes.